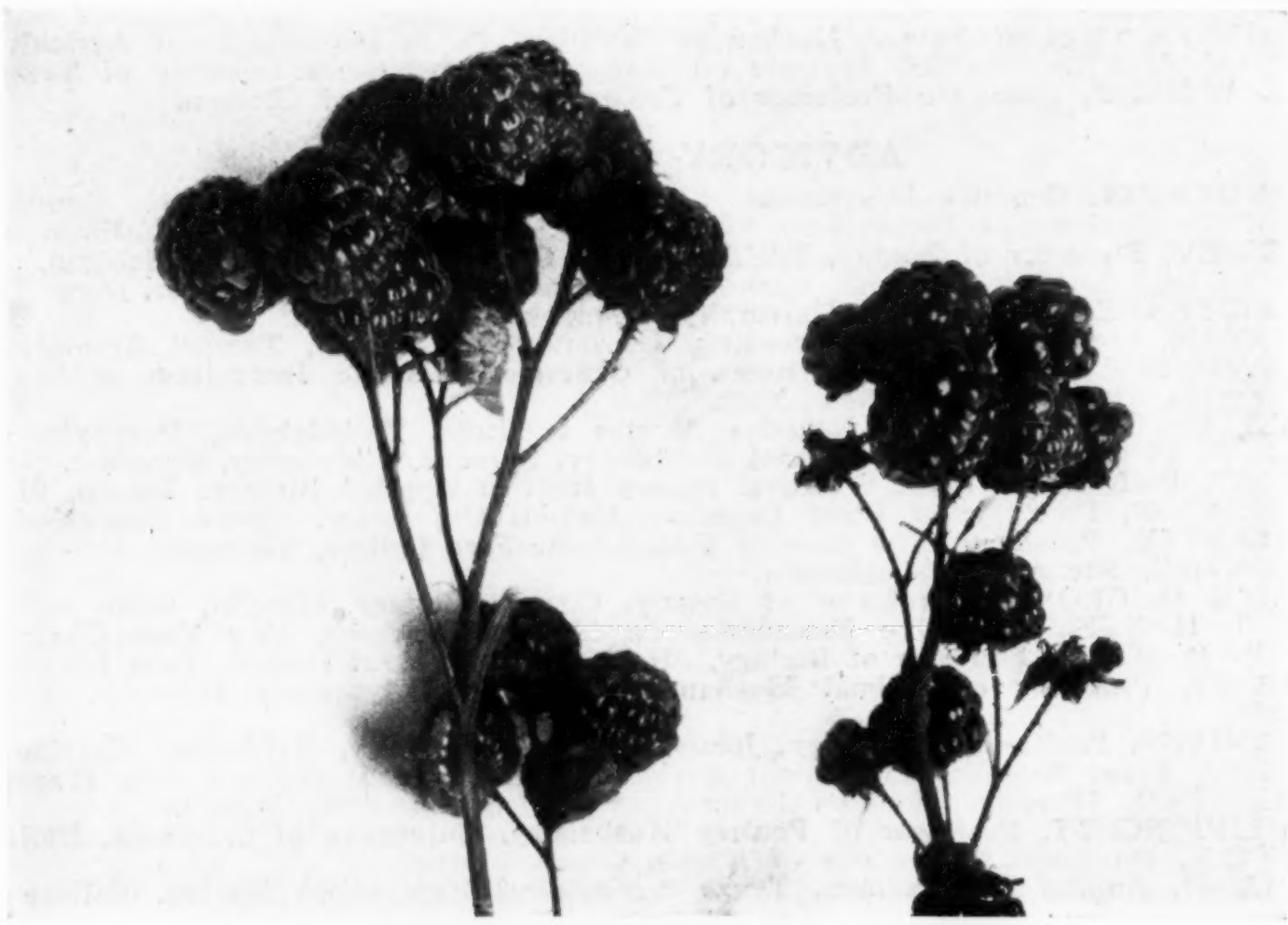
NOV 9 1926

PERIODICAL ROOM
GENERAL LIBRARY
UNIV. OF MICH.

The Journal of HEREDITY

A monthly publication devoted to Plant Breeding Animal Breeding and Eugenics



A Prolific Raspberry Hybrid

Education and Size of Family in China
J. B. Griffing

Inheritance in Rust Resistance
E. B. Mains

Raspberry Breeding Experiments
George M. Darrow

The Harvard Birth Rate

Standardized Pedigree Charts

The Natural Increase of Mankind

September, 1926 Vol. 17, No. 9

The American Genetic Association

President, David Fairchild Vice-President, W. E. Castle Secretary, C. E. Leighty
Treasurer, Fred M. Berthrong

EDITORIAL BOARD

M. DEMEREC R. R. GRAVES L. C. DUNN
WILSON POPENOE GEORGE M. DARROW PAUL POPENOE

Members of the Council are ex-officio members of the Editorial Board

Managing Editor: ROBERT C. COOK

COUNCIL

W. E. CASTLE, Professor of Zoology, Harvard University, and Research Associate of the Carnegie Institution of Washington.
LEON J. COLE, Professor of Genetics, University of Wisconsin.
G. N. COLLINS, Botanist, U. S. Department of Agriculture, Washington, D. C.
O. F. COOK, Bionomist in Charge of Breeding Investigations, U. S. Department of Agriculture.
DAVID FAIRCHILD, Agricultural Explorer in Charge, U. S. Department of Agriculture.
HARRY V. HARLAN, Senior Agronomist in charge of Barley Investigations, U. S. Department of Agriculture.
C. E. LEIGHTY, Agronomist in Charge of Eastern Wheat Investigations, U. S. Department of Agriculture.
VERNON KELLOGG, Chairman, Division of Educational Relations, National Research Council, Washington, D. C.
J. H. KEMPTON, Bureau of Plant Industry, U. S. Department of Agriculture.
E. W. SHEETS, Chief of Animal Husbandry Division, U. S. Department of Agriculture.
FREDERICK ADAMS WOODS, Lecturer on Biology, Massachusetts Institute of Technology.
SEWALL WRIGHT, Associate Professor of Zoology, University of Chicago.

ADVISORY COMMITTEE

W. S. ANDERSON, Genetics Department, University of Kentucky, Lexington, Kentucky.
E. B. BABCOCK, Genetics Department, University of California, Berkeley, California.
E. A. BESSEY, Professor of Botany, Michigan State College, East Lansing, Michigan.
A. F. BLAKESLEE, Plant Genetist, Carnegie Institution, Cold Spring Harbor, New York.
J. K. BREITENBECHER, McGill University, Montreal, Canada.
W. E. BRYAN, Professor of Plant Breeding, University of Arizona, Tucson, Arizona.
C. B. DAVENPORT, Director, Department of Genetics, Carnegie Institution of Washington, Cold Spring Harbor, L. I., New York.
J. A. DETLEFSEN, Professor of Genetics, Wistar Institute, Philadelphia, Pennsylvania.
RUSSELL W. DUCK, Professor of Animal Husbandry, Syracuse University, Syracuse, New York.
E. M. EAST, Professor of Plant Genetics, Bussey Inst. of Applied Biology, Boston, Mass.
R. A. EMERSON, Professor of Plant Breeding, Cornell University, Ithaca, New York.
C. P. GILLETTE, President, The Genetic Foundation, Fort Collins, Colorado.
C. M. GOETHE, Sacramento, California.
FREDERICK O. GROVER, Professor of Botany, Oberlin College, Oberlin, Ohio.
ROBERT T. HANCE, Rockefeller Foundation for Medical Research, New York City.
HARRISON R. HUNT, Professor of Biology, Michigan Agricultural College, East Lansing, Mich.
R. E. HUNT, Professor of Animal Husbandry, Virginia Polytechnic Institute, Blacksburg, Virginia.
H. S. JENNINGS, Professor of Zoology, Johns Hopkins University, Baltimore, Maryland.
D. F. JONES, Plant Breeder, Connecticut Agricultural Experiment Station, New Haven, Conn.
F. B. LINFIELD, Director, Montana Experiment Station, Bozeman, Montana.
WM. A. LIPPINCOTT, Professor of Poultry Husbandry, University of California, Berkley, Cal.
C. C. LITTLE, President, University of Maine, Orono, Maine.
JAY L. LUSH, Animal Husbandman, Texas Agricultural Experiment Station, College Station, Texas.
H. H. NEWMAN, Professor of Zoology, University of Chicago, Chicago, Ill.
T. S. PALMER, Expert in Game Conservation, U. S. Dept. of Agriculture, Washington, D. C.
JOHN H. PARKER, Professor of Agronomy, Kansas State College, Manhattan, Kansas.
MRS. CHARLES C. RUMSEY, Wheatley Hills, Westbury, Long Island.
THOMAS W. SALMON, Professor of Psychiatry, Columbia University, New York City.
JOHN M. SCOTT, Vice Director, Florida Agricultural Experiment Station, Gainesville, Florida.
JOHN W. SCOTT, Professor of Zoology, University of Wyoming, Laramie, Wyoming.
A. D. SHAMEL, Pomologist, U. S. Department of Agriculture, Riverside, California.
GEORGE H. SHULL, Professor of Biology, Princeton University, Princeton, New Jersey.
W. W. SMITH, Professor of Animal Husbandry, Purdue University, Lafayette, Indiana.
CHARLES R. STOCKARD, Professor of Anatomy, Cornell University, New York City.
A. B. STOUT, Director of Laboratories, New York Botanical Gardens, New York City.
W. T. SWINGLE, Plant Physiologist in Charge of Breeding Investigations, U. S. Department of Agriculture, Washington, D. C.
LOU D. SWEET, Seedsman, Denver, Colorado.
E. L. THORNDYKE, Professor of Educational Psychology, Columbia University, New York City.
W. H. TOMHAVE, American Aberdeen-Angus Breeders' Association, Chicago, Ill.
H. E. WALTER, Professor of Biology, Brown University, Providence, Rhode Island.
H. J. WEBBER, Director, Citrus Experiment Station, Riverside, California.
E. N. WENTWORTH, Armour's Bureau of Agr'l Research and Economics, Chicago, Illinois.
P. W. WHITING, Department of Biology, University of Maine, Orono, Maine.
JOHN A. WIDTSOE, 47 E. South Temple St., Salt Lake City, Utah.

The

Journal of Heredity

VOL. XVII, NO. 9 SEPTEMBER, 1926

CONTENTS

STUDIES IN RUST RESISTANCE ..... E. B. MAINS 313

MANIFESTATIONS OF LIFE (A Review) 325

HERITABLE CHARACTERS OF MAIZE ..... JOHN B. WENTZ 327

THE BIOLOGICAL FITNESS OF WORLD PUBLICATIONS (A Review) 329

INHERITANCE OF WEBBED TOES SUMMARIZED (A Review) 330

EDUCATION AND SIZE OF FAMILY IN CHINA ..... J. B. GRIFFING 331

HOW THE WORLD IS MADE (A Review) 337

RASPBERRY BREEDING EXPERIMENTS ..... GEORGE M. DARROW 339

NEWS AND NOTES 349

The JOURNAL OF HEREDITY is published monthly by the
AMERICAN GENETIC ASSOCIATION

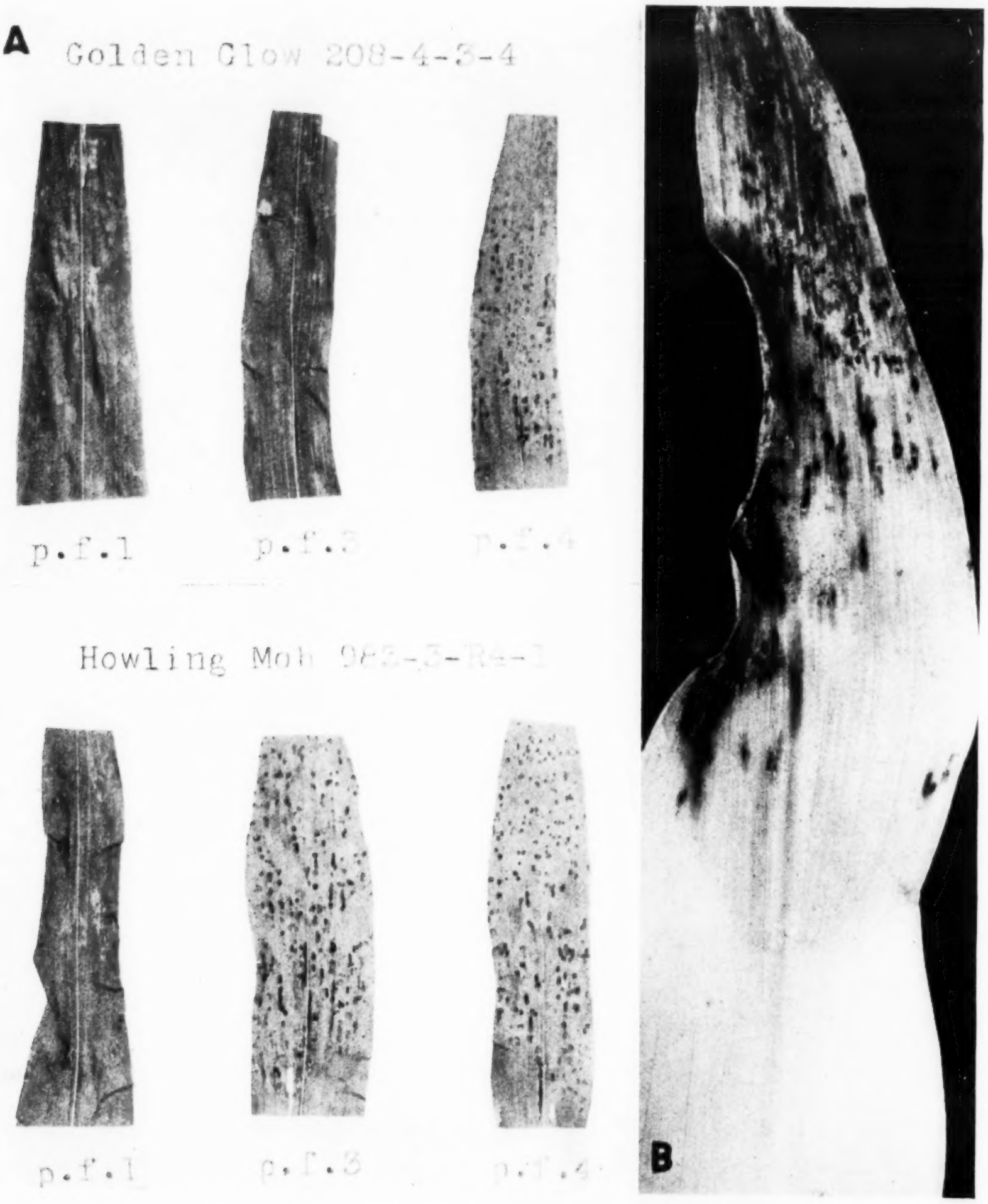
At 1918-32 Harford Avenue, Baltimore, Md., and
Victor Building, Washington, D. C.

Address communications regarding editorial matters and the business management of the Association to Room 306, Victor Building, Washington, D. C.

Entered as second class matter February 24, 1923, at the post office at Baltimore, Maryland. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized December 20, 1918. Contents copyrighted 1926 by the American Genetic Association. Reproduction of articles or parts of articles permitted only upon request, for a proper purpose, and provided due credit is given to the author and to the JOURNAL OF HEREDITY, Washington, D. C.

Date of Issue of this number, October 28, 1926

$3.50 *a Year; 35c the Copy*



REACTION OF MAIZE SEEDLINGS TO THREE PHYSIOLOGIC FORMS OF RUST

Frontispiece

(*A*) Differences in reaction of two inbred lines of corn, Golden Glow 208-4-3-4 and Howling Mob 983-3-R4-1 to three physiologic forms of *Puccinia Sorghi* (reduced). (*B*) Leaf from an albino plant of Early Yellow Dent corn (51-15-1-2-4) heavily rusted with *Puccinia Sorghi*. (×3).

The problem of producing rust resistant varieties is complicated by the fact that a number of physiological forms of rust are known. These are distinguished by differences in the reaction of pure lines of the host species, as is shown above. In this case both inbred lines of maize are resistant to physiological form 1 (p. f. 1), while they differ in their reaction to p. f. 3 of the rust. Thus a selection of the host species which is resistant to some forms may be susceptible to others. To be of maximum agronomic value a variety would have to be resistant to all or many physiologic forms of several species of pathogenic fungi.

STUDIES IN RUST RESISTANCE*

E. B. MAINS
Purdue University

THE control of the diseases caused by rust fungi by either the discovery or the development of resistant varieties of their respective hosts has received much attention from numerous investigators† in various parts of the world. The degree of success has varied considerably with the rust studied. It is my purpose to summarize some of the results‡ which have been obtained in a study of a number of rusts since 1918, and state briefly some of the conclusions which may be drawn.

In these studies, various degrees of resistance and susceptibility to each rust have been found to occur within their host species[16,17], (Figures 1, 2, 3, 4). The most susceptible hosts show an abundance of large, well developed uredinia without at first any pronounced chlorosis of the host. Less susceptible hosts show fewer and smaller uredinia, occasionally with chlorosis. While these latter are in a sense resistant, the term has been restricted by several investigators,§ especially in greenhouse studies of seedlings, to include those hosts in which necrosis results from infection. With increase in resistance, there is a decrease in the number and size of the uredinia and an increase in the proportion of necrotic areas without uredinia. In the most highly resistant varieties only faint flecks occur. In our investigations, the leaf rust of wheat, *Puccinia triticina* Eriks., has been studied the most extensively, and more or less high resistance has been noted in approximately 96 strains¶ of wheat out of the 2,515 studied. To the leaf rust barley, *Puccinia anomala* Rostr., 49 strains of barley out of the 697 studied, showed a very high resistance in greenhouse tests (Figure 1, *A* 4) and a still larger number were resistant in the field. In corn, approximately 103 of the 3,618 inbred strains, one-, two-, three- and four-year selfs, showed at least a few individuals highly resistant[19] to the rust of corn, *Puccinia Sorghi* Schw. (Figure 2), and by fur-

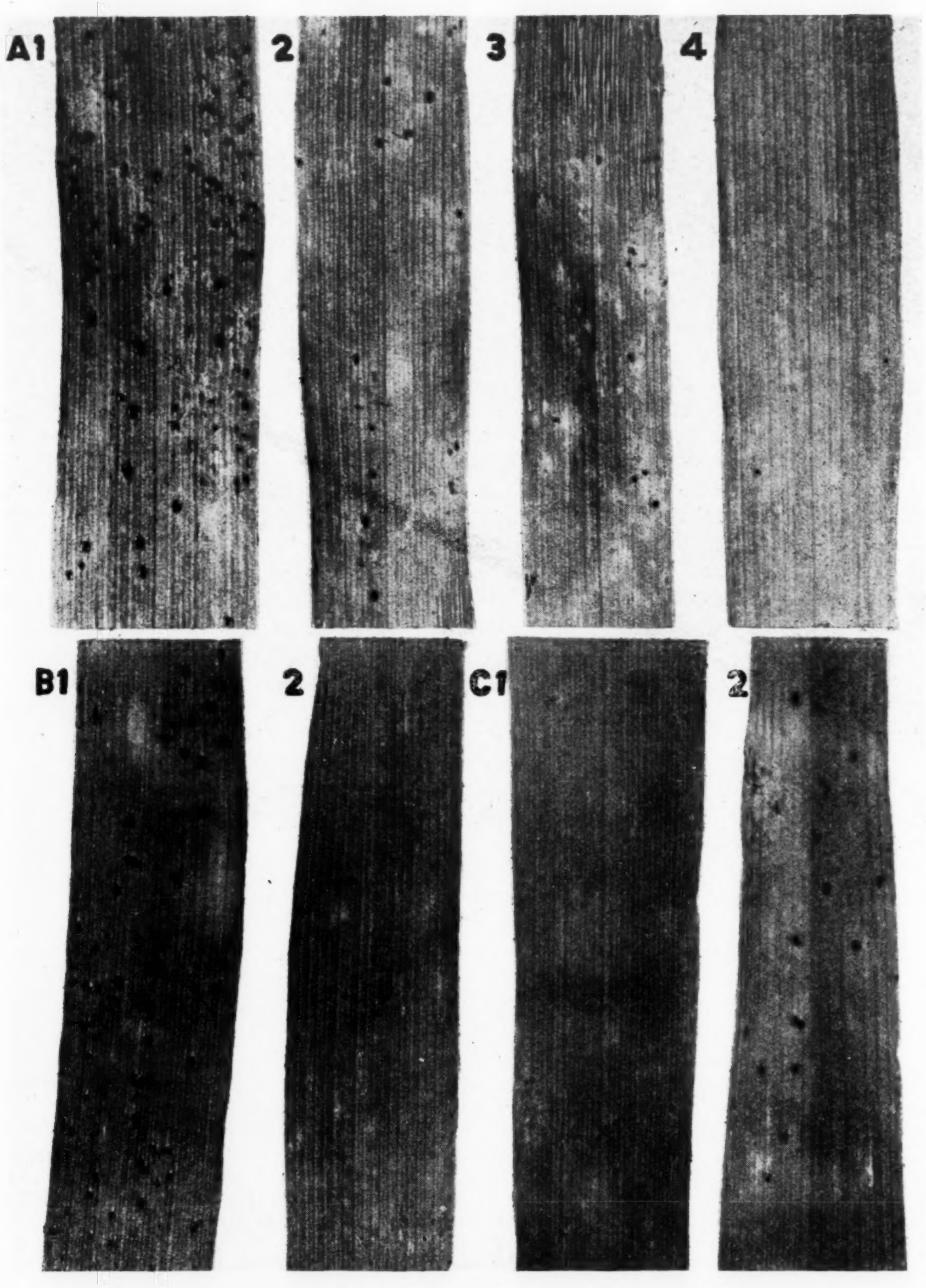
*Invitation paper read at the joint meeting of Section O, American Association for the Advancement of Science, and the American Phytopathological Society at Kansas City, December 31, 1925. Published with the approval of the Director as a contribution of the Department of Botany, Purdue University Agricultural Experiment Station.

†In the literature cited only a small number of references are given. The literature dealing with rust resistance is too extensive for complete review in this short paper.

‡The results with the leaf rusts of the cereals and wild grasses have been obtained in cooperative investigations between the Department of Botany, Purdue University Agricultural Experiment Station, the Office of Cereal Investigations, United States Department of Agriculture, and the Department of Plant Pathology, Kansas Agricultural College Extensive field studies of wheat varieties have been made possible also through the cooperation of the Agricultural Experiment Stations of Georgia, Tennessee, and Wisconsin. Smaller sowings have been studied at a number of other Agricultural Experiment Stations. The other rusts mentioned in this paper are being studied as a part of the rust projects of the Department of Botany, Purdue University Agricultural Experiment Station.

§HAYES, STAKMAN and AAMODT[6], MAINS[12], MAINS and JACKSON[16], MAINS and LEIGHTY[17], STAKMAN and LEVINE[22].

¶In this paper the term strain is used to signify a group of individuals within a variety differing from other strains of the variety in some agronomic character such as yield, etc. The term line is here used to signify a group of individuals which by inbreding has been found to be homozygous for rust reaction (resistance or susceptibility). In many cases the strains of such self-fertilized species as wheat and barley are pure for rust reaction. In some cases strains of such species may contain physiologic lines distinguishable by their rust reaction.



SUSCEPTIBILITY AND RESISTANCE TO RUST

Figure 1

(*A*) Leaves of four strains of barley showing several types of reaction to physiologic form 1 of the leaf rust *Puccinia anomala*. 1—Leaf of Wisconsin Winter C. I. 519, susceptible. 2—Leaf of Club Mariout C. I. 261, moderately susceptible. 3—Leaf of Peruvian C. I. 935, resistant. 4—Leaf of Horsford C. I. 877, highly resistant. (*B*) Differences in reaction of two lines of a variety to physiologic form 1 leaf rust of barley. 1—Oderbrucker C. I. 1137, susceptible. 2—Oderbrucker C. I. 957, highly resistant. (*C*) Differences in reaction of a barley line, Oderbrucker C. I. 940 to physiologic forms of leaf rust. 1—Resistant to physiologic form 1. 2—Susceptible to physiologic form 2.

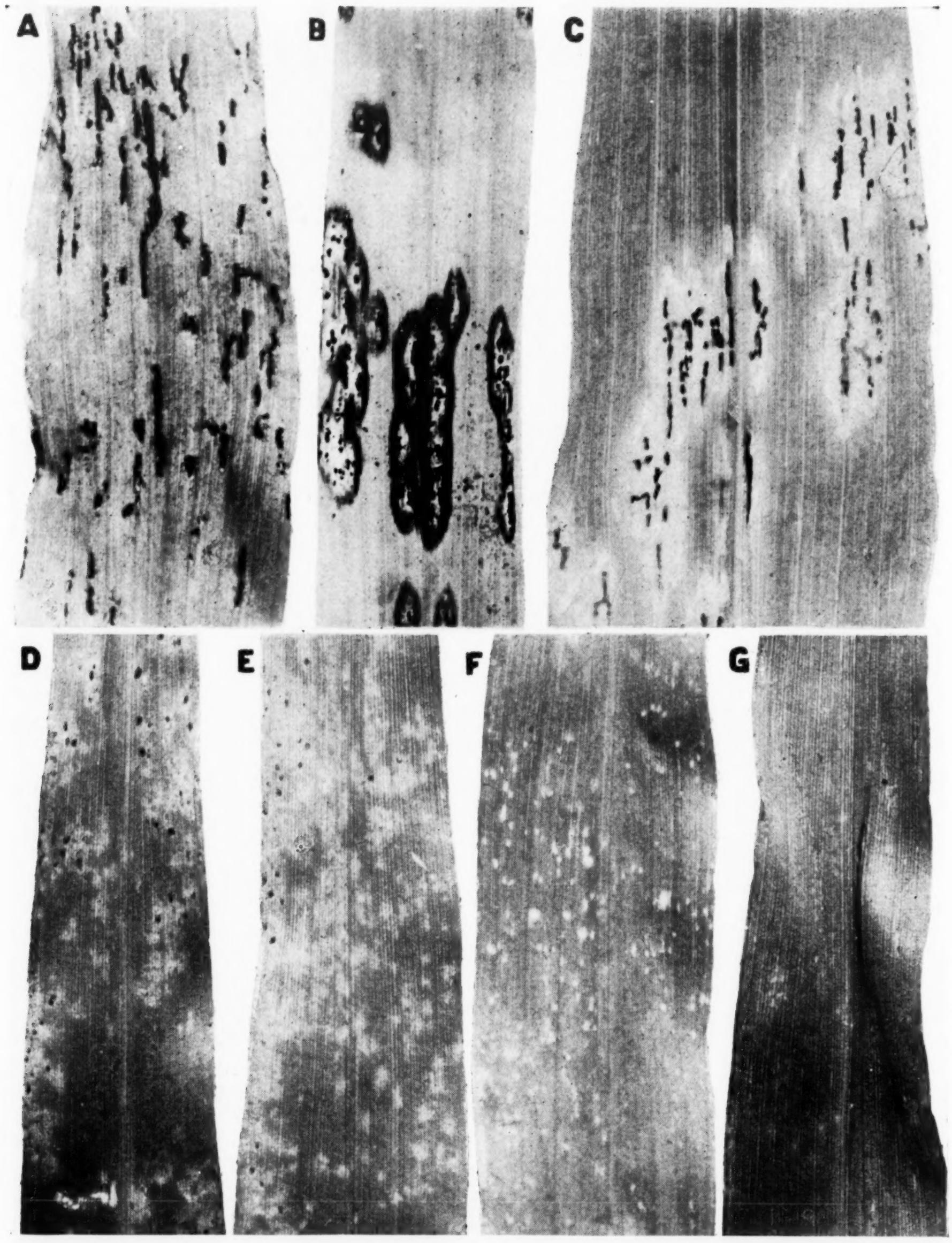
ther inbreeding lines pure for resistance have been obtained. Individuals highly resistant to the leaf rust of rye, *Puccinia dispersa* Eriks.[17] were found in each of the 68 strains of rye studied and from these several rust-resistant lines have been developed.

High resistance is found not only in the cultivated cereals but also within the species of wild grasses. Thus in *Secale montanum* Guss., supposedly the wild ancestor of rye, individuals were discovered showing the various types of reaction to *Puccinia dispersa* found in rye (Figure 3). Individuals resistant and susceptible to *Puccinia agropyrina* Eriks., the leaf rust of quack grass, *Agropyron repens* (L.) Beauv., have been found. A number of species of wild grasses, such as *Elymus canadensis* L., *E. condensatus* Presl., and *Hystrix Hystrix* (L.) Millsp., have been found to contain individuals resistant and individuals susceptible to *Puccinia montanensis* Ellis. In *Andropogon scoparius* Michx. plants resistant and plants susceptible to *Puccinia Andropogonis* Schw. exist (Figure 6, *C*).

Among the clovers, plants of red, (*Trifolium pratense* L.) and crimson, (*T. incarnatum* L.) have shown high resistance (Figure 4, *C-G*) to *Uromyces fallens* Kern, and in white clover, *Trifolium repens* L., numerous strains have shown a very high resistance to *Uromyces Trifolii* (Hedw.) Lev. Individuals resistant to the alfalfa rust, *Uromyces Medicaginis* Pass. have been found in strains of such varieties as Grimm, Cossack, Vale, Argentine, Dakota, and New Zealand. By selection and inbreeding, a number of lines of snap-dragons have been developed which show considerable resistance to *Puccinia Antirrhini* Diet. and Holw. (Figure 4, *A-B*). The variety White Matchless (Figure 3, *B*) has shown a very high resistance to carnation rust, *Uromyces Carophyllinus* (Schrank) Wint. These results, taken with those obtained by other investigators studying a number of other species of rusts, indicate that resistance is more or less prevalent among the hosts of the various rusts and that resistant individuals or lines probably can be found among hosts of all the rusts provided a sufficient range of material is studied.

Rust Resistance Wide Spread

It has been found also that resistance is not limited to a small group of closely related or similar varieties of the hosts of the rusts studied, but often is present in varieties of quite diverse types. Resistance to the leaf rust of wheat has been found in the durum, emmer, spelt, poulard, polish, einkorn, and common types, the club wheats being the only major group in which it has not so far been discovered although club types have been bred which are resistant. In the common wheats, resistance has been found in certain strains of such diverse groups as are represented by the varieties Bobs, Fultz, Kofod, Resaca, Democrat, Gladden, Valley, Fulcaster, Hussar, Pesterboden, Turkey, Kanred, Dixon, Imperial Amber, Norka, Mediterranean and Webster, including winter and spring, bearded and beardless, hard and soft, and white- and red-seeded types. In barley, marked leaf-rust resistance has been found in both six-rowed and two-rowed, hooded and awned, white- and blue-seeded, including certain lines of such varieties as Oderbrucker C. I. 940, Brewing C. I. 657, Featherstone C. I. 1120, Horsford C. I. 507, Black Hulless C. I. 1097, Nepal C. I. 262, Heil's Hanna No. 3 C. I. 682, Black Arabian C. I. 202, etc. In corn, high resistance has been found[19] in sweet, pop, and dent types including certain inbred lines of Golden Bantam, Golden Rod, Howling Mob, Ball Pop, Golden Glow, Early Yellow Dent, and Reid's Yellow Dent. In this connection it is also of interest to note that albino segregates often are as highly susceptible as normal green plants (Frontispiece, *B*) and that both resistant and susceptible plants occur in many other types of corn.



REACTION OF MAIZE SEEDLINGS TO RUST

Figure 2

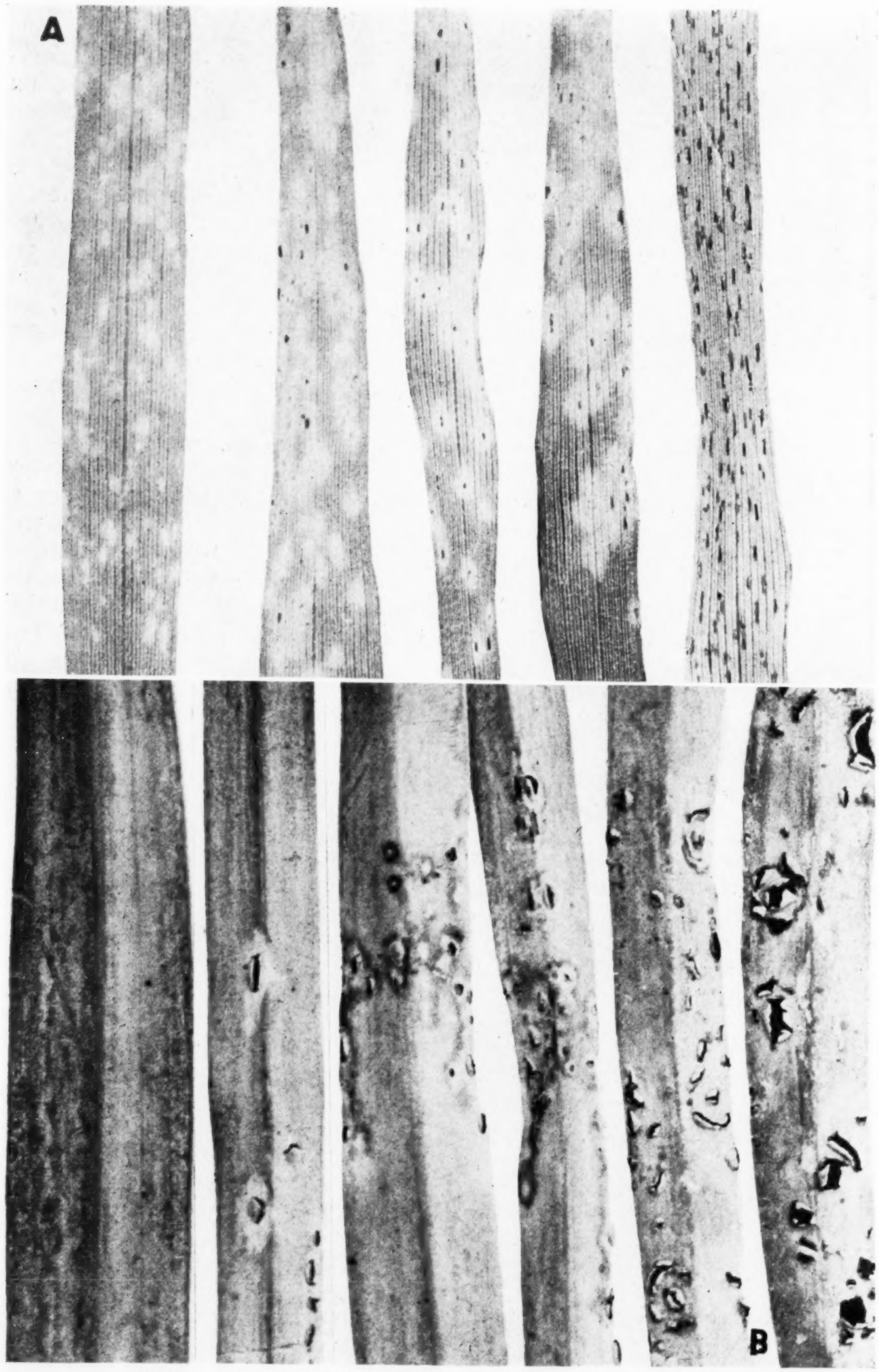
Some of the various types of reaction shown by different lines of corn in the seedling stage in the greenhouse to *Puccinia Sorghi* p. f. 1. (*A*) Very susceptible, uredinia abundant, large; (*B*) Moderately susceptible, uredinia moderate in number and size, purple circle surounding infected areas; (*C*) Moderately resistant, uredinia accompanied by chlorosis; (*D*) Moderately resistant, uredinia small, moderately abundant, necrosis prevalent; (*E*) Very resistant, uredinia small, few, necrosis abundant; (*F*) Highly resistant, no uredinia, necrosis abundant; (*G*) Highly resistant, no uredinia only faint flecking evident. The leaves illustrated are from lines of (*A*) Golden Glow; (*B*) Arlington Prolific; (*C*) Pink Sweet; (*D, E*) Country Gentleman; (*F*) Golden Glow; (*G*) Country Gentleman. (×3).

Rust resistance, though sometimes associated with resistance to other diseases, occasionally is found associated with susceptibility to such diseases as bunt, loose smut, stem rust, powdery mildew, and scab in wheat; root rot and smut in corn; powdery mildew in barley (Figure 6, *A*); stem rust and powdery mildew in rye, and powdery mildew in red clover. It therefore would appear, in these particular hosts, at least, that resistance to leaf rust is due to a different factor or factors than those responsible for resistance to each of the other diseases mentioned.

While rust resistance appears in very diverse types of the cultivated hosts of these rusts, within a group of individuals of such great similarity as an agronomic variety of wheat, there may exist lines showing marked differences[16] in reaction to rust. Thus, for example, in the variety Turkey, 16 lines were found showing high susceptibility to certain cultures of leaf rust, while two lines were practically immune from the same cultures. The same has been found true in some of the barley varieties (Figure 1, *B*1-2) and it is apparently the usual situation in the cross-pollinated hosts studied. It is not safe, therefore, to draw general conclusions concerning host varieties from the results obtained in the study of one strain or line of a variety. Rust resistance, in many cases at least, is dependent upon distinct physiologic characters. Many of the agronomic varieties have been developed without paying much, if any, attention to rust resistance, as they were bred for morphologic type and yield. They therefore may contain lines physiologically distinguishable.

Factors Involved in Rust Resistance

The question now arises whether in rust resistance we are dealing with one factor or several. Apparently we have to do with at least several. As has been indicated already, under a given set of conditions, as in the seedling stage in the greenhouse and to a pure culture of rust, we have different host lines showing various types or degrees of resistance. Lines also differ in the degree to which their resistance can be modified. We know that, in general, a reduction in the host vigor is reflected by a reduced development of the rust even in the most susceptible varieties. This apparently is correlated with the delicate balance in adjustment of the rusts with their susceptible hosts. In many cases of resistance there is apparently more or less a lack of proper physiologic balance [2,3,21]. The degree of this incompatability is influenced undoubtedly also by the vigor of the host. The resistance of some host lines apparently is much more easily influenced by slight changes in environment than is that of others. Hussar C. I. 4843 often shows a considerable fluctuation in reaction in the greenhouse to a given culture of leaf rust of wheat, as indicated by the number and size of uredinia and in amount of necrosis produced without reaching the point where it can be classed as susceptible. On the other hand, such varieties as Malakoff often show a very pronounced resistance which varies but little to the same culture of rust. Other lines of wheat may show a marked difference in reaction under diverse conditions. Thus Kanred has been more or less highly resistant to leaf rust of wheat in a number of field nurseries but when inoculated in the seedling stage in the greenhouse with the rust from the same nurseries it has shown high susceptibility. Several strains of Nepal barley have shown high susceptibility to barley leaf rust in the seedling stage in the greenhouse, but when exposed to the same culture of rust in the field they rusted only a trace to 25 per cent as compared with adjacent varieties showing 100 per cent. The same has been found true for certain lines of corn. It may be that in same cases these changes are morphologic, making it difficult for the rust to develop in the host, as has been found by Hursh[7] in the case of stem rust. Changes in physiology induced by different en-



RUST REACTION IN GRASS AND CARNATIONS

Figure 3

(*A*) Types of reaction shown by individuals of *Secale montanum* to *Puccinia dispersa* p. f. 1. Each leaf represents the reaction of a different plant of the grass. (×3). (*B*) Types of reaction shown by different varieties of carnations to *Uromyces caryophyllinus*. From left to right, first leaf from White Matchless, highly resistant, next three leaves from the variety Surprise, moderately resistant, the last two leaves from the variety White Enchantress, susceptible. (×3).

vironmental conditions or developmental stages of the host probably also play an important part in a number of these instances. In the cases just discussed, it is to be noted that the change has been from susceptibility in the greenhouse to resistance in the field where for practical purposes resistance is important.

It is of interest, to digress for a moment, to note that, as in the leaf rust of wheat, a rust species in one phase of its development may be restricted not only to a few wheat species but even to certain strains of these wheats. In another phase of its development it is unable to infect wheat at all but develops in such distantly related and distinct hosts as species of Thalictrum[8]. This is a very remarkable change in physiologic reaction, more especially as in the two different phases of its development the rust shows great stability.

Physiologic Forms of Rust

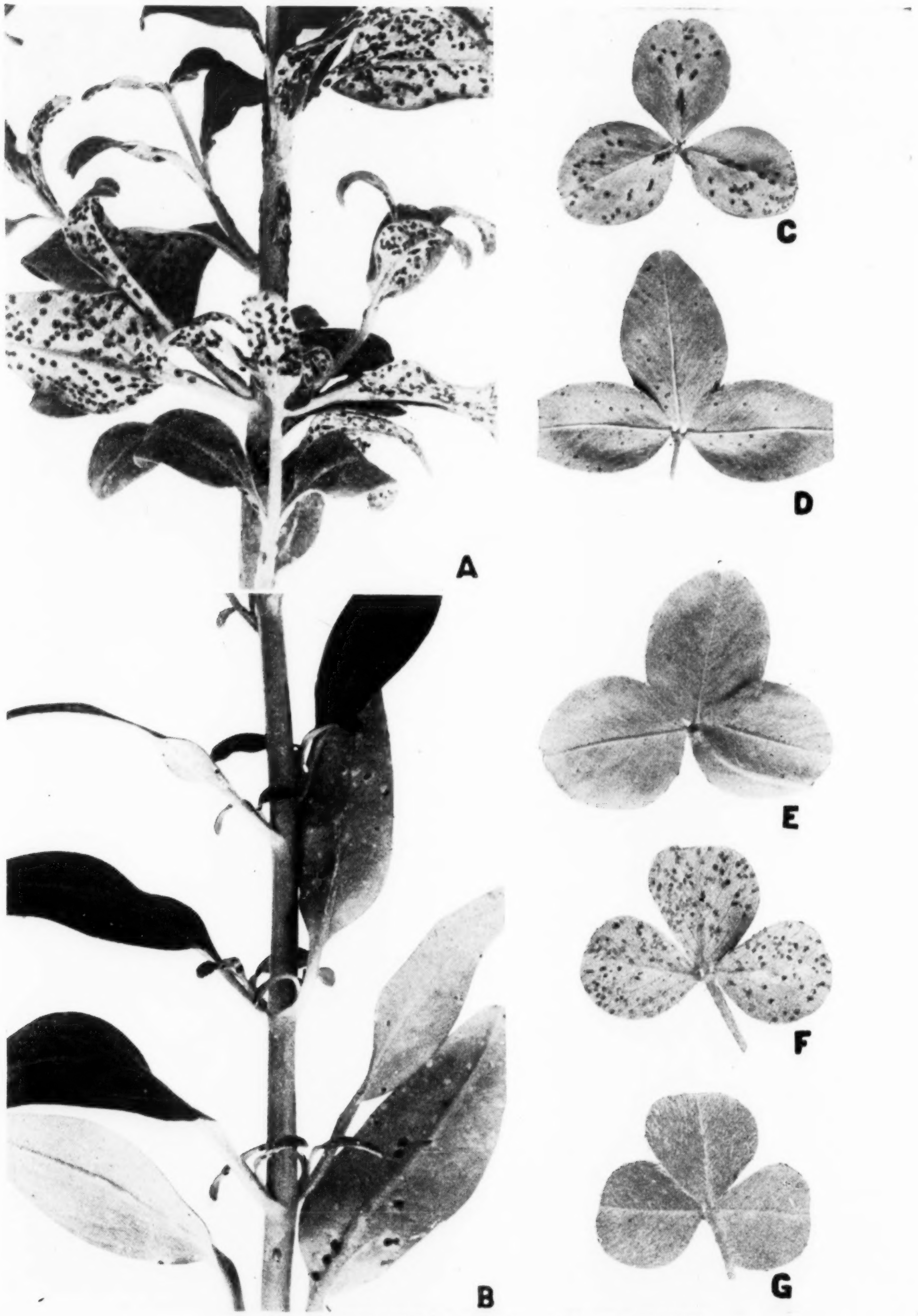
The differences just mentioned have been confined to the same culture of rust under diverse conditions. On the other hand, marked resistance may be shown by a line of a host species in one locality or during one year, while in another locality or another year it may be very susceptible. The same is true of different cultures of some of the rusts studied in the greenhouse. This, as has been shown by Stakman and his associates[22,23] for stem rust, is due largely to differences within the rust species, or the presence of a number of physiologic forms varying in ability to parasitize different host lines. In our studies, twelve such physiologic forms have been isolated in the leaf rust of wheat. These differ strikingly in their action upon seedlings of various lines of wheat in the greenhouse as has been described elsewhere[16].

In the rust of corn, four such physiologic forms have been isolated. While several of the inbred lines of corn differ in their reaction to these physiologic forms, the latter can be separated by the use of three inbred lines (Frontispiece, *A*). To physiologic form 1, Golden Glow 208-4-3-4, Howling Mob 983-3-R4-1 and Ball Pop D222-5-13-2-1 are all resistant in the seedling stage in the greenhouse. Physiologic form 2 differs from 1 in that Ball Pop is susceptible. To physiologic form 3, Golden Glow is resistant, while Howling Mob and Ball Pop are susceptible. To physiologic form 4, all three lines are susceptible.

Two physiologic forms of the leaf rust of rye have been distinguished by the reaction of an inbred line of Abruzzes rye, S2229-23-29-11 (Figure 6, *B*). This inbred line of rye has been uniformly very highly resistant to physiologic form 1 of the leaf rust of rye, while to physiologic form 2 it is very susceptible.

Two physiologic forms of the leaf rust of barley have been distinguished by differences in reaction of the lines Oderbrucker C. I. 940 (Figure 1, *C*), Featherston C. I. 1120, and Horsford C. I. 5057, all of which show high resistance to physiologic form 1 of *Puccinia anomala* and are more or less susceptible to physiologic form 2. It is to be noted that not only are certain host lines distinguished readily only by their rust reaction but the strains of the rust are also so distinguished. It is therefore not only important to work with host lines pure for the rust-resistant character, but also with pure cultures of the rust parasite in critical studies of rust resistance. This may be insured by starting rust cultures from a single spore[12,15,16] and inbreeding host lines for the rust-resistant character.

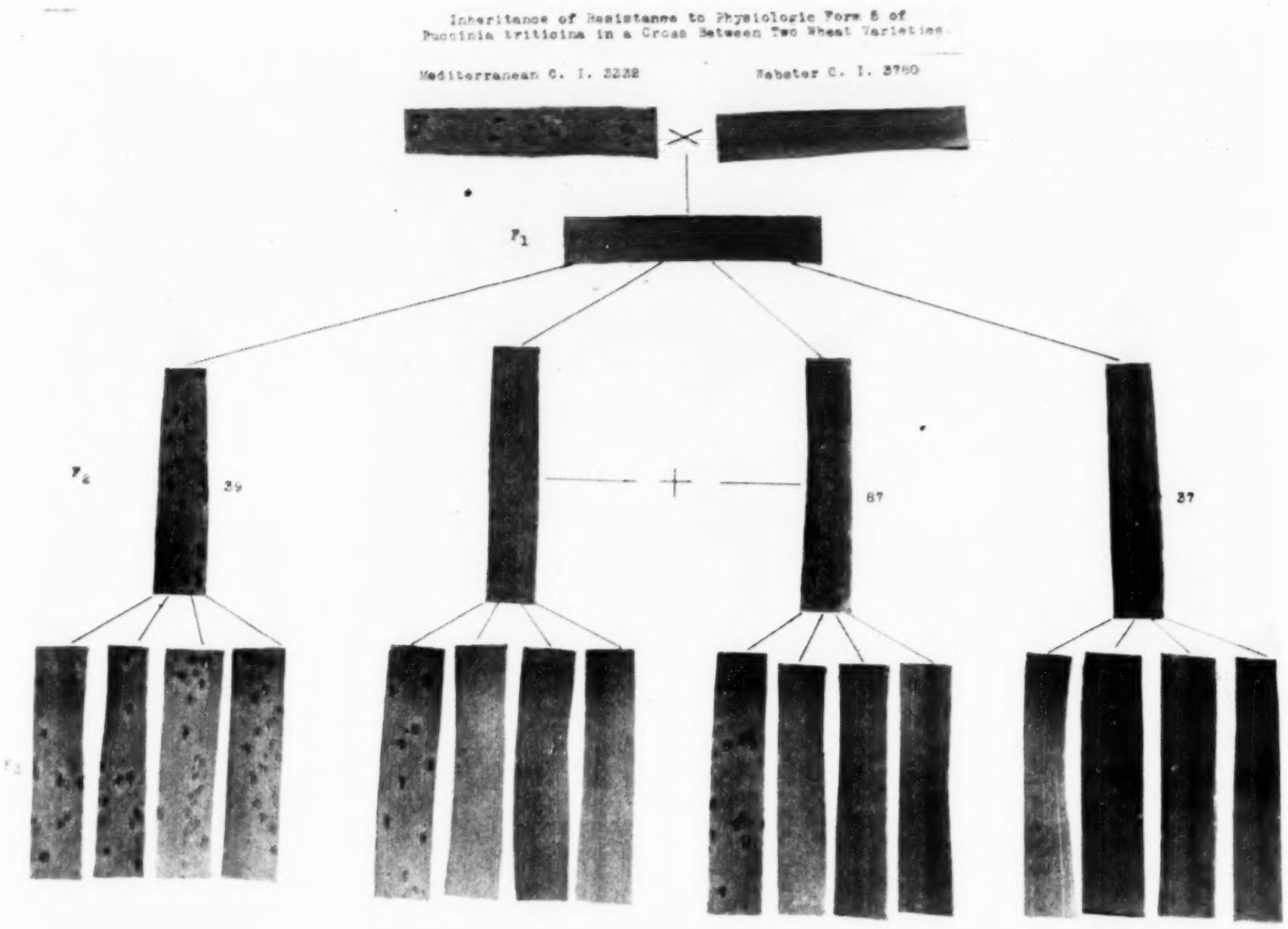
It would appear that while rust resistance is prevalent among the hosts of the various rusts, it may be produced by a number of different factors. Not only may these various factors differ in the symptoms which they produce and in the requirements necessary for production but, even when the manifestation is the same, the factors responsible may be different. The



RUST IN SNAPDRAGONS AND CLOVER

Figure 4

(*A*) Plant showing high susceptibility of an inbred line (G8S) of snapdragons to *Puccinia Antirrhini.* (*B*) Plant showing marked resistance of an inbred line (12-3-14) of snapdragons to *Puccinia Antirrhini* (reduced). (*C-E*) Reaction of selections from red clover (Ohio 2135) to *Uromyces fallens,* (*C*) susceptible. (*D*) moderately resistant. (*E*) highly resistant (reduced). (*F-G*) Reaction of selections from crimson clover (2054) to *Uromyces fallens,* (*F*) susceptible, (*G*) highly resistant (reduced).



INHERITANCE OF RUST RESISTANCE

Figure 5

Inheritance of resistance to *Puccinia triticina* p. f. 5 in a cross between Mediterranean C. I. 3332 (highly susceptible), and Webster C. I. 3780 (highly resistant). The F_1 individuals were highly resistant. The F_2 segregated in the ratio of 39 susceptible to 124 highly resistant. In the F_3 37 of the latter bred true, 87 gave susceptible and resistant progeny. All the F_2 susceptible plants bred true in the F_3 (reduced).

resistance of Malakoff C. I. 4898 to physiologic form 3 of the leaf rust of wheat appears the same as that of Democrat to physiologic form 9; yet Malakoff is highly susceptible to form 9 and Democrat is highly susceptible to form 3. The factors responsible for resistance in the two lines apparently are different.

Inheritance of Rust Resistance

The results of studies in the inheritance of resistance point to the same conclusions. The resistance shown by some lines of wheat was inherited as a simple dominant character as, for example, the resistance of Webster C. I. 3780 in a cross with Mediterranean C. I. 3332 (Figure 5). The resistance of other lines was found to be inherited as a simple recessive character[18]. In some crosses, heterozygous individuals showed a reaction intermediate between that shown by the resistant and susceptible parents. In one cross studied by C. O. Johnson[18], this intermediacy was of a very unusual nature, heterozygous individuals in the seedling stage classed as susceptible, showed more or less resistance in the shooting and heading stages, reversing the ratio of susceptible and resistant individuals from 3:1 to 1:3. We also have found, as Puttick[20] and Aamodt[1] have for stem rust, that when crosses are made between two lines of wheat, each of which is susceptible to the form to which the other is resistant, the resis-

tance of each of the two lines was inherited as a separate simple factor. Also the two factors for resistance to the two physiologic forms were combined in a definite proportion of the progeny. Therefore, it would appear that what we call resistance oftentimes is the similar manifestation of a number of different factors operative within living plants.

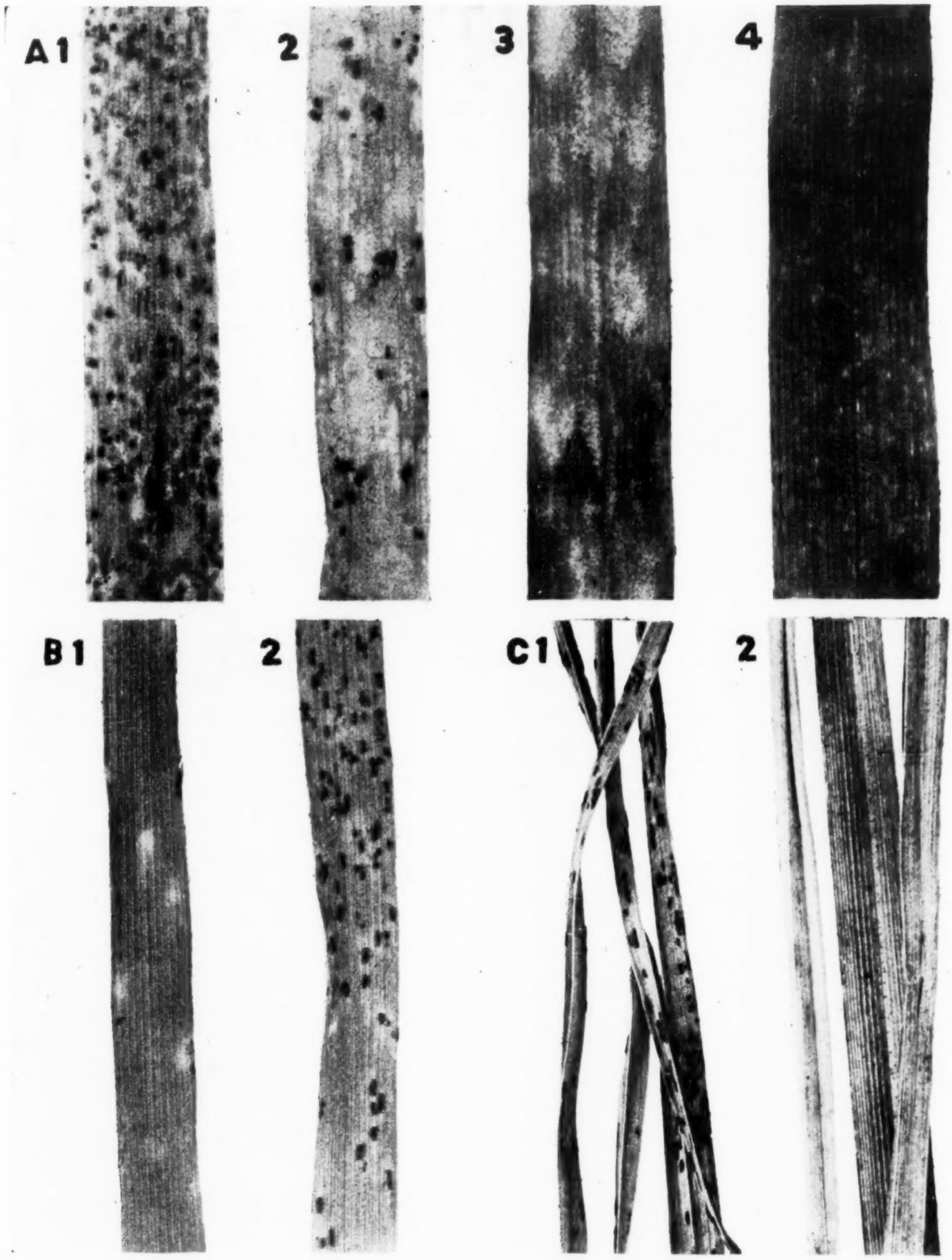
Certainly we are dealing with a very complex situation. But pause a moment to consider that with which we are dealing or, perhaps, our ignorance of that with which we are dealing. In the rusts, we have obligate parasites which no one has so far grown successfully except within a living host. Why are they obligate parasites? As they do not appear to attack directly and destroy the host protoplasm for their food, the conditions for their development are apparently those to be found within the host cell[10], their metabolism being closely adjusted to and linked with the metabolism of their hosts. Is the metabolism of all lines of wheat the same? In what way do they differ? Only in the final products? May they not differ in the process and intermediate products formed, which may or may not be favorable to rust development? May not the metabolism of the various forms of rust differ in a corresponding manner? It is true that we are unable at present to answer these questions. But is this not true of a large number of plant characteristics? What is the exact nature of the processes which bring about their final product?

Control of Rust

It is obvious that the presence of different physiologic forms in the rusts complicates seriously the control of such pathogens through rust resistance unless strains of the host exist which are highly resistant to all the physiologic forms. Whether such strains exist is not easy to answer as it is unlikely that we are acquainted with all the physiologic forms. Certainly we have not studied all the host strains. In the case of wheat, which we have studied most extensively, only one line of emmer has been found that can be considered resistant in the greenhouse and field to all forms thus far studied. In the field a number of strains of the durums, emmers, and einkorn have shown more or less resistance in the eastern United States for the past seven years.

Among the common wheats, Yeoman C. I. 6223 has been resistant in all field tests but has thus far shown no marked resistance in the greenhouse. Kanred has shown more or less pronounced resistance in 54 out of 63 field tests but in the greenhouse it has been resistant to only one physiological form. Various lines of Turkey and Beloglina have shown similar proportions of resistance in the field with resistance to a larger number of forms in the greenhouse. Webster C. I. 3780 has been resistant in 13 out of 18 tests in the field and to 8 of 12 physiologic forms in the greenhouse. Hussar C. I. 4843 has been resistant in 20 out of 33 tests in the field and to 9 of the 12 physiologic forms when grown in the greenhouse. Other similar examples might be cited.

All of these lines of wheat, especially the durums and emmers, are restricted in their adaptability. Because of the difficulties involved, no extensive studies have been made in these investigations using the durums and emmers in crosses with common wheats. A combination of the resistance found in these two groups with common wheats would, however, help considerably toward a solution of the problem. Kanred, one of the best of the common wheats, is adapted to the hard winter wheat area. From studies[18] of 42 crosses made by the writer in cooperation with Dr. C. E. Leighty, with Kanred as the leaf-rust-resistant parent, it has been found that the field resistance shown by Kanred can be combined with other types of wheat. Several different selections from these have been made and are showing con-



BARLEY INOCULATED WITH BOTH RUST AND MILDEW

Figure 6

(*A*) Differences in reaction of barley lines when inoculated with both leaf rust, *Puccinia anomala* (p. f. 1), and powdery mildew, *Erysiphe graminis*. 1—Goldfoil C. I. 928 susceptible to rust and resistant to mildew. 2—Hanna C. I. 1122 susceptible to both rust and mildew. 3—Oderbrucker C. I. 957 resistant to rust and susceptible to mildew. 4—Common Chile C. I. 663 resistant to both rust and mildew. (*B*) Difference in reaction of rye, Abruzzes S2229-23-29-11 to physiologic forms of leaf rust, *Puccinia dispersa*: 1—To physiologic form 1, resistant. 2—To physiologic form 2, susceptible. (*C*) Differences in reaction of two plants of Beard grass, *Andropogon scoparius*, to *Puccinia Andropogonis*. 1—Leaves from susceptible plant. 2—From resistant plant.

siderable promise for the soft winter wheat area. As already stated, it appears possible, by crossing lines resistant to different physiologic forms, to combine many of the factors responsible for resistance and thus synthesize a strain extremely resistant to all forms of the rust. Numerous strains of the various hosts have so far shown great promise of resistance to each of the other rusts studied. Their value will depend upon the number of physiologic forms occurring in the various rusts and their reaction to them. Cross-pollination of corn, rye, clover, and alfalfa introduces difficulties in the development of pure resistant lines in these crops. This necessitates artificial self-pollination. With rye and red clover, the prevalent self-sterility introduces still further complications. The discovery of lines of fair self-fertility in these[4,5,9,15] gives promise of overcoming this difficulty. Once pure resistant lines are obtained in the cross-pollinated crops, there still remains the problem of maintaining this purity in a practical way.

It should be noted that a number of the strains most promising for their resistance to the rusts studied in these investigations have been reported as outstanding for resistance to other diseases. Among the wheats Kanred, Webster C. I. 3780, and a number of durums and emmers[22,24] are resistant to several physiologic forms of stem rust; Hussar C. I. 4843[25] to bunt; Norka C. I. 4377 to powdery mildew[13] and possibly scab[14]; lines of Abruzzes rye[15] to stem rust and powdery mildew; certain lines of barley to mildew (Figure 6, *A*); certain lines of corn to smut and root rot; and a number of red clover selections[11] to mildew. Other examples might be given but those cited will serve to indicate the disease-resistant potentiality of a number of varieties and selections of the above named crops and some of the possibilities for the control of several diseases through the use of relatively few varieties.

In conclusion, it would appear from the foregoing that rust resistance probably is to be found in some form or other among lines of most host species. While the resistance of the various lines in the same host species or even in the same variety may appear similar, yet the reaction of such lines to various physiological forms of the rusts and the inheritance of such resistance indicates that a number of distinct factors cause the same manifestation of resistance. Therefore, in studies of the inheritance of resistance, and especially in studies concerning the nature of resistance, it is important that this be kept constantly in mind. The host studied should be lines as far as possible genetically pure for resistance to a pure culture of the rust in order to obtain uniform results. It is also to be expected that various investigators working with different pure lines of the host and different physiologic forms of the rust will reach diverse conclusions concerning the nature of the factors producing resistance.

Literature Cited

1. Aamodt, O. S. The inheritance of growth habit and resistance to stem rust in a cross between two varieties of common wheat. *Jour. Agr. Research* 24:457-470. 1923.

2. Allen, R. F. A cytological study of infection of Baart and Kanred wheats by *Puccinia graminis tritici*. *Jour. Agr. Research* 23:131-152. 1923.

3. ———————. Cytological studies of infection of Baart, Kanred and Mindum wheats by *Puccinia graminis tritici* forms 3 and 19. *Jour. Agr. Research* 26:571-604. 1924.

4. Brewbaker, H. E. Self-fertilization in rye (Abstract). *Anat. Rec.* 26:283-284. 1924.

5. Fergus, E. N. Self-fertility in red clover. *Ky. Agr. Exp. Sta.* Circ. 29. 36 pp. 1922.

6. Hayes, H. K., E. C. Stakman and O. S. Aamodt. Inheritance in wheat of resistance to black stem rust. *Phytopathology* 15:371-387. 1925.

7. Hursh, C. R. Morphological and physiological studies on the resistance of wheat to *Puccinia graminis tritici* Erikss. and Henn. *Jour. Agr. Res.* 27:381-412. 1924.

8. Jackson, H. S. and E. B. Mains. Aecial stage of the orange leaf rust of wheat, *Puccinia triticina* Erikss. *Jour. Agr. Research* 22:151-172. 1921.

9. Kirk, L. E. Artificial self-pollination of red clover. *Sci. Agr.* 5:179-189. 1925.

10. Mains, E. B. The relation of some rusts to the physiology of their hosts. *Amer. Jour. Bot.* 4:179-220. 1917.

11. ————————. Differences in susceptibility of clover to powdery mildew. *Proc. Ind. Acad. Sci.* 1922:307-313. 1923.

12. ————————. Notes on greenhouse culture methods used in rust investigations. *Proc. Ind. Acad. Sci.* 33:241-257. 1924.

13. ————————. Wheat resistant to mildew. *Erysiphe graminis.* (Abstract). *Phytopathology* 14:48. 1924.

14. ————————. Observations concerning the disease susceptibility of cereals and wild grasses. *Proc. Ind. Acad. Sci.* 34:289-295. 1925.

15. ————————. Rye resistant to leaf rust, stem rust and powdery mildew. *Jour. Agr. Research,* 32:201-221. 1926.

16. ————————and H. S. Jackson. Physiologic specialization in the leaf rust of wheat, *Puccinia triticina* Erikss. *Phytopathology,* 16:89-120. 1926.

17. ———————— and C. E. Leighty. Resistance in rye to leaf rust, *Puccinia dispersa* Erikss. *Jour. Agr. Research* 25:243-252. 1923.

18. ————————, C. E. Leighty and C. O. Johnston. Inheritance of resistance to leaf rust, *Puccinia triticina* Erikss in crosses of common wheat, *T. vulgare Vill. Jour. Agr. Research,* 32:931-972. 1926.

19. ————————, J. F. Trost and G. M. Smith. Corn resistant to rust, *Puccinia Sorghi.* (Abstract). *Phytopathology* 14:47-48. 1924.

20. Puttick, G. F. The reaction of the F_2 generation of a cross between a common and a durum wheat to two biologic forms of *Puccinia graminis. Phytopathology* 11:205-213. 1921.

21. Stakman, E. C. Relation between *Puccinia graminis* and plants highly resistant to its attack. *Jour. Agr. Research* 4:193-200. 1915.

22. ———————— and M. N. Levine. The determination of biologic forms of *Puccinia graminis* on *Triticum* spp. *Minn. Agr. Exp. Sta. Tech. Bul.* 8, 10 pp. 1922.

23. ————————, M. N. Levine and D. L. Bailey. Biologic forms of *Puccinia graminis* on varieties of *Avena* spp. *Jour. Agr. Research* 14:1013-1018. 1923.

24. ————————, ———————— and Fred Griffee. Webster, a common wheat resistant to black stem rust. *Phytopathology* 15:691-698. 1925.

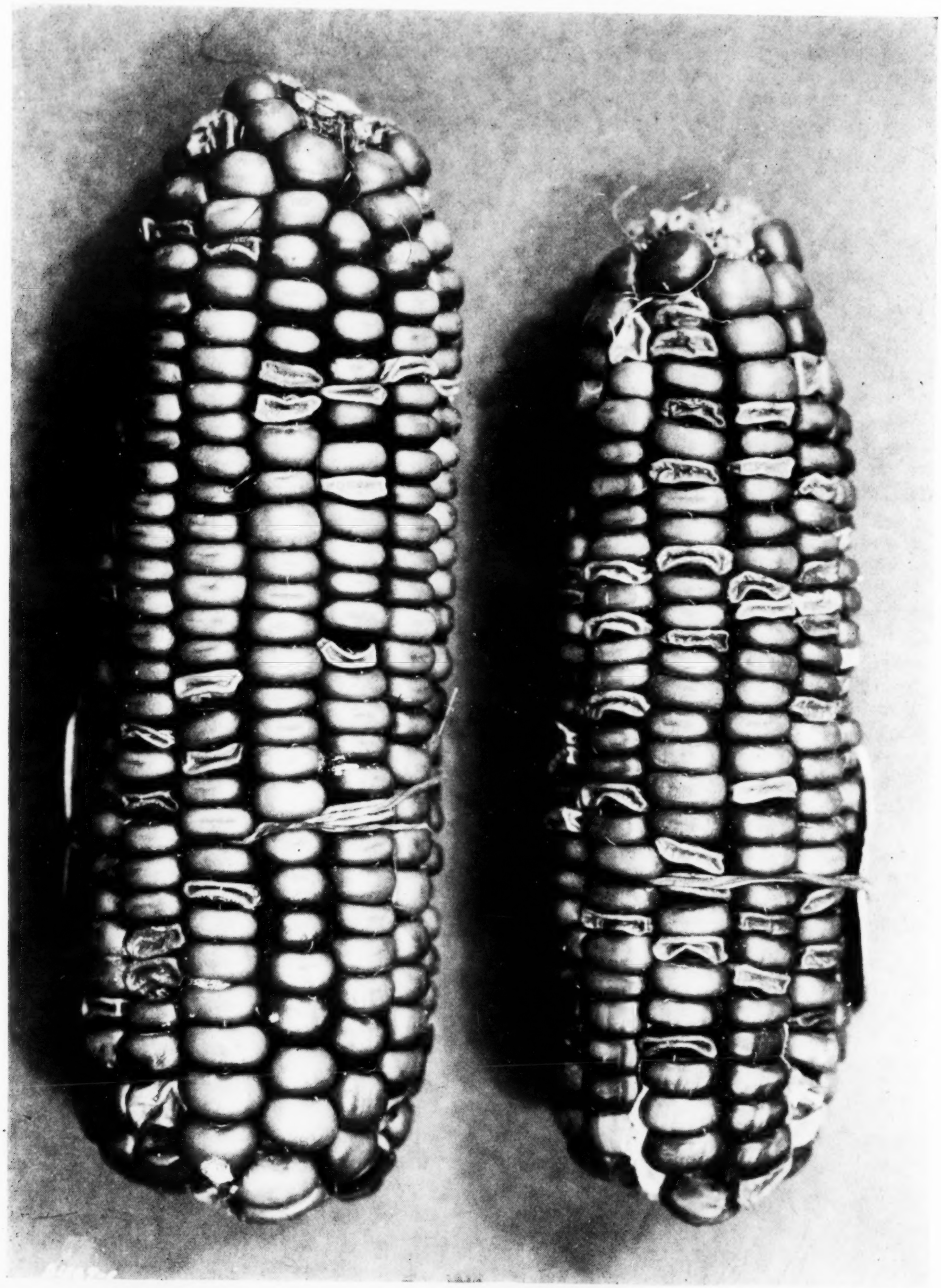
25. Tisdale, W. H., et al. Relative resistance of wheat to bunt in the Pacific coast states. *U. S. Dept. Agr. Bul.* 1299. 30 pp. 1925.

Manifestations of Life

Stufen des Lebens, eine Einführung in die Physiologie, by August Pütter. Pp. 580; price, $1.8; Verlag von George Stilke, Berlin, 1923.

The author (professor of physiology in Kiel) has produced a work that is a worthy successor of Jacob Moleschott's *Kreislauf des Lebens,* which was a standard for half a century. Dr. Pütter has written a good book on biology in the broadest sense. The various manifestations of living matter are brought into relation with one another, in a way particularly well adapted to orient the student. Heredity, in 25 pages, is discussed in a large and reasonable manner. The volume, which is attractively printed, deserves a wide and lasting circulation.

P. P.



EARS SEGREGATING FOR CONCAVE SEEDS

Figure 7

These two self-pollinated ears are segregating for concave and normal seeds. The ear on the right has approximately 25 per cent of concave seeds, while the one on the left falls considerably short of this theoretical proportion based on the assumption of a single Mendelian factor pair.

HERITABLE CHARACTERS OF MAIZE

XXVI—Concave

JOHN B. WENTZ
Iowa State College, Ames, Iowa.

IN THE spring of 1923, seed of a number of strains of corn segregating for defective endosperm was received from Professor R. A. Emerson of Cornell University. Among this collection of defective endosperm types there was one which looked particularly interesting. Normal seed from a segregating ear of this strain was planted and a few self-pollinations made during the summer. The selfed ears obtained indicated that the defective seeds were definitely inherited, and in the spring of 1924 more seed was planted for the purpose of getting additional data on the inheritance of this character. A row each of the normal and of the defective seeds was planted but the defective seed failed to produce any plants. Thirty self-pollinated ears were obtained in the row planted from the normal seed, and also a number of crosses were made with other strains. This report is based on the data obtained in 1923 and 1924, together with a few more self-pollinations in the original strain, as well as in the crosses, in 1925.

The 1925 crop was grown in the plant breeding garden at Cornell University, while the 1923 and 1924 crops were grown at Ames.

This new defective type, which has been given the name "concave," with the symbol "cv," has somewhat the appearance of sugary corn, but is more shrunken and lacks the glassy or translucent appearance of sugary seeds. It also looks something like "shrunken" but differs from it in being more shrunken or shriveled. Not only the crown of the seed is drawn in, but the sides as well, present concave surfaces.

The original strain was crossed with both sugary and shrunken strains and in each case normal starchy seeds were obtained and the new type reappeared in the next generation easily distinguishable from both the sugary and the shrunken seeds.

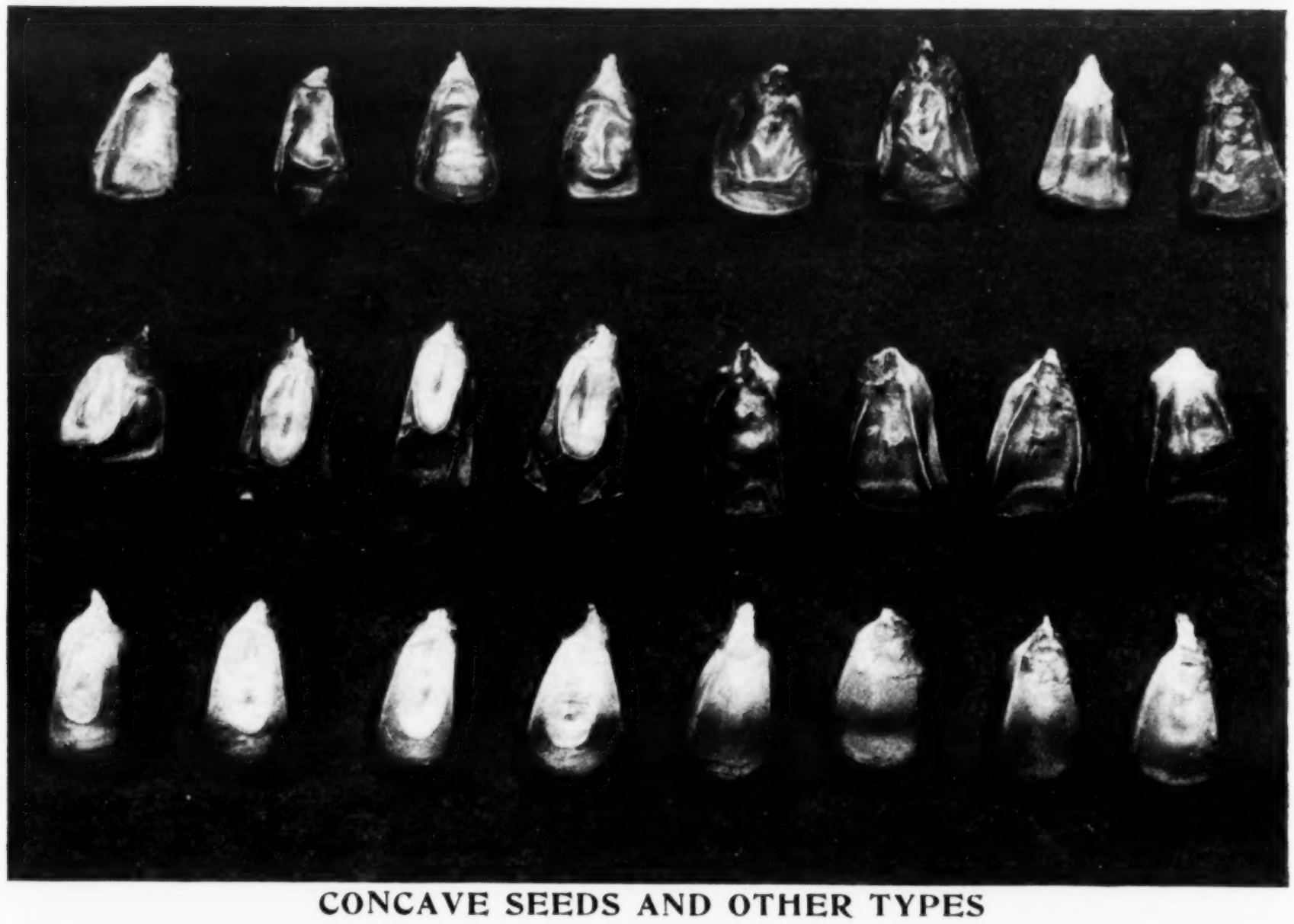
Germination tests have been made of a number of ears grown in 1923 and 1925 and it was found that the defective seeds germinate a little better than fifty per cent, although defective seed planted in the field in the spring of 1924 did not produce plants. In order to grow plants from the defective seeds, it probably will be necessary to give plantings of this seed special care. Possibly the seed will have to be germinated in the laboratory or green house and transplanted.

Total starch and sugar determinations were obtained of composite samples of the concave seeds as compared to normal starchy and sugary samples. The following figures show the results of these determinations.*

	Starchy	*Sugary*	*Concave*
Percentage total sugar	2.09	8.63	10.75
Percentage starch....	48.97	14.93	15.07

It is seen that the concave seeds are relatively high in sugar and low in starch. Evidently this new defective is caused by some factor which interferes with starch formation similar to the situation in sugary corn.

*Chemical analyses were made by Mr. Leonard Johnson, fellow in Botany. The figures are on the basis of dry weight as determined by the method of Quisumbing and Thomas.



CONCAVE SEEDS AND OTHER TYPES

Figure 8

Starchy, sugary and concave seeds. The bottom row shows the concave seeds as compared to sugary seeds in the middle row and starchy seeds in the top row.

Inheritance of Concave

In the years 1923, 1924* and 1925 a total of 41 plants have been self-pollinated in rows from normal seed of segregating ears of the original strain. Of the 41 plants self-pollinated, 26 segregated for the new defective, giving a total of 4535 normal to 1463 concave seeds. Assuming that concave is due to a simple Mendelian factor, the ratio of segregating to non-segregating plants, according to theory, should have been 27.4 to 13.6 and the ratio of normal to concave seeds 4498.5 to 1499.5. In the ratio of segregating to non-segregating plants there is a deviation from theory of only 1.4 ± 1.87, and in the ratio of normal to defective seeds there is a deviation of 36.5 ± 22.60. These figures are close enough to theory to assume that concave is due to a single factor.

Progenies were grown in 1925 at Ithaca from six different crosses which were made in 1924 and a number of self-pollinations made. As previously mentioned, some of the original strain was also grown alongside these crosses and selfed. When all of the self-pollinated ears were harvested and seeds counted, it was found that the ears from the original strain gave the usual 3 to 1 ratios, while those from the crosses fell far short of the theoretical number of defective seeds. There was great variation in the percentage of defective seeds on the ears from the crosses ranging from a few per cent up to a little above the expected 25 per cent. Evidently, in each of the six crosses, factors were introduced which affected the number of defective seeds. The nature of these factors is not yet known. Similar

NOTE:—Since this paper was submitted for publication Dr. P. C. Mangelsdorf of the Connecticut Agricultural Experiment Station has reported what is no doubt the same character under the name "Brittle."—*J. B. W.*

cases have been observed in sugary corn by Correns[2], Emerson[3], and Jones[4] and in waxy endosperm by Kempton[5], and a paper by Brink[1] presents what is known as to the cause of these odd ratios.

Literature Cited

1. Brink, R. A. Mendelian ratios and the gametophyte generation in Angiosperms. *Genetics* 10:359-394. 1925.

2. Correns, C. Bastarde zwischen Maisrassen mit besonderer Berucksichtigung der Xenien. *Bibliotheca Bot.* 53:1-161. 1901.

3. Emerson, R. A. A possible case of selective fertilization in maize hybrids (Abstract). *Anat. Rec.* 29:136. 1924.

4. Jones, D. F. Selective fertilization among the gametes from the same individuals. *Nat. Acad. Sci.* 10:218-221. 1924.

5. Kempton, J. H. The inheritance of waxy endosperm in maize. *U. S. Dept. Agric. Bur. Plant Ind., Prof. Bull.* 754. 1919.

THE BIOLOGICAL FITNESS OF WORLD POPULATIONS

A Review

IF iteration will accomplish anything it may safely be predicted that the reading public soon will be convinced that the population of the world is increasing. The latest treatise on world population is a statistical inquiry into the biological fitness (as measured by the ratio of births to deaths) of world populations insofar as records are available* With a few minor exceptions the author finds that the races of the earth are increasing in numbers, the births exceeding deaths in virtually all countries. Although there is a negative correlation between the magnitude of the birth-death ratio and the rate of its increase, indicating that size of population is subject to limiting factors, there remains the fact that despite such checks population continues to increase.

Even such major catastrophes as the World War and the influenza pandemic only temporarily checked the rate of increase. The author compared the birth-death ratio for the years 1918-1921, as predicted from the years preceding the war, with the rate actually observed and found that in two years following the war the predicted values practically agreed with the observed rate. Such findings should interest those archaeologists who believe the extinction of races to be due to war and pestilence.

Like all recent critical inquiries into questions of increasing world population this study leads to the conclusion that if the present day standards are to be improved or even maintained birth limitation measures are greatly to be desired. The author realizes that to be effective the limitation of births must be practiced by that element of the population now most prolific, and appreciates that the general adoption of restrictive measures can only be obtained by educating the thoughtless.

While modestly recognizing the small likelihood that the facts presented in his book will have any influence upon present-day practices, the author, somewhat naively it appears, believes that eventually the population of the world will be reduced to the extremity of thinking, and when that time arrives the advantage to be derived from voluntary limitation of births will be appreciated. The optimistic note will ring flat to those who hold that, unless present-day practice is modified, long before the pressure of population forces the prolific masses to restrict the number of their offspring, those who are able to think will have been eliminated.

It is questionable how far one is

*The Natural Increase of Mankind, by J. Shirley Sweeney, with an introduction by William H. Welch. The Williams & Wilkins Co., Baltimore. 1926. Price $4.00

ethically justified in attempting to shape human affairs in accordance with his own ideas of excellence, especially when these ideas involve the wholesale elimination or restriction of family lines. Interference with the trend of population might be construed as intellectual selfishness but there is every reason to project into the future the results of our present habits quite apart from the adoption of indicated remedies.

The presence of more people might be considered by many as oppressive, but it must be admitted that a large increase in population would not be unwelcome to others. If the policy of the greatest good for the greatest number is to prevail in population as in politics, the fact may as well be accepted that enormously greater populations are in order even to the extent of per capita food reduction. Unquestionably there are people who revel in the quantity rather than the quality of anything, not excluding humans, and it seems reasonable to infer that those who feel isolated unless domiciled in a row house on a twenty-foot street will welcome the hosts the biometricians predict.

For these people Dr. Sweeney's book will make pleasant reading and it is to be hoped that he will benefit by their patronage.

J. H. Kempton.

Inheritance of Webbed Toes Summarized

THE NATURE AND INHERITANCE OF WEBBED TOES IN MAN, *by* WILLIAM L. STRAUS, JR., in the *Journal of Morphology and Physiology*. Vol. 41 No. 2, March 5, 1926.

This important article is a survey of the entire subject of zygodactyly, and is probably the most careful review of the subject and its literature that has appeared. The author's conclusions are based on original examination of material at the Carnegie Laboratory of Embryology at Baltimore, the collection of five new pedigrees from life, and a re-examination of those appearing in the literature.

The author finds that webbing of fingers or toes is caused by an arrest of local development, resulting in the retention of the normal embryonic webbing. This usually affects only the skin between the digits, the skeleton being unaffected, although the extensor tendons of the toes may occasionally be fused. He finds that zygodactyly is not confined to man, but frequently appears in other mammals, especially in the Macropodidae (kangaroos) and certain rodents and insectivores, where it may be associated with aquatic habits, and in primates. Among the latter, it occurs in certain lemurs, in Cercocebus, a west African genus of monkeys, and in the gibbons. In the siamang, the largest gibbon, the occurance of webbed toes is one of its characters of generic distinction, hence its generic name, *Symphalangus syndactylus*. The author found webbing to occur in the allied genus Hylobates as well, which fact might tend to lessen the generic distinction between the two genera.

The author then examines the pedigrees of eleven families in which zygodactyly occured, and discusses the nature of its inheritance in each. Six of these pedigrees were collected from the literature of the subject, four of them having been published in the *Journal of Heredity*, and five pedigrees are new.

In the majority of these families the author finds zygodactyly to be inherited as an ordinary mendelian dominant. In two other cases it is either a mendelian or sex-linked dominant. In three instances it appears to be a mendelian recessive, or else arose in these families as a mutation. In one case it follows the distribution of the Y-chromosome, appearing in all of the males but in none of the females. One other pedigree is interesting in that the webbing is present in but one of apparently identical twins.

Charles F. Stein, Jr.

EDUCATION AND SIZE OF FAMILY IN CHINA

J. B. GRIFFING
University of Nanking, Nanking, China

THE frequent studies that have been made of families of American College graduates and other educated groups, which set forth in a striking manner a rate of reproduction that diminishes rapidly in proportion to the degree of culture, suggest that a similar study of families in other countries would be of interest.

One might naturally expect that a favorable birth differential between educated and uneducated classes would scarcely be found in the world today. Least of all would one expect to find it in China. An investigation of Chinese families made by the writer, however, indicates that for the regions studied, the cultured groups show an increase, as far as surviving children are concerned, over the lower cultural levels that is as marked as the more rapid reproduction of the lower classes in the United States.

Methods of Collecting Data

The investigation which disclosed this fact was directed toward the determination of the factors which affect population increase in China. As there are no available statistics comparable to Western census reports, the method used was the study of population groups through typical samples from several different localities. These were selected in a considerable number of places and studied in three different ways.

One class of data was secured from women patients in hospitals. The investigator in each case was a trained nurse who asked each patient the questions on the survey blank as though they were a part of the history of the case. Information obtained in his way may be considered as particularly accurate not only as to births, but also deaths, for the Chinese woman in the hospital will speak comparatively freely to her nurse of babies that have been discarded at birth or that died at an early age and have been dropped from the reckoning.

The items included in this hospital survey were: age, age married, age of husband, age of husband at death if not living, family occupation, religion, years of schooling if any, feet bound or unbound, economic condition, number of living children by sex and age, number of deceased children by sex and age at death, and number of stillbirths.

Hospitals in four cities, Peking, Nanking, Tsinan, and Shanghai and in four rural sections, Nanhsuchow, Techow, Hwanghsien, and Luchowfu, cooperated in securing the information.

The direct survey was a second method used in securing data. A man thoroughly trained in the making of surveys visited typical villages securing information somewhat similar to that obtained in the hospitals. In order to insure accuracy he worked through the introduction of well known local leaders such as pastors, teachers or village elders who allayed suspicion and aided in putting the questions and checking up the answers. In any instance where the villager gave suggestion of evasion or inaccuracy the information taken was discarded. Eight different rural communities were surveyed in this way.

The direct survey possessed the advantage of taking a fairer cross section of the population than could be obtained by studying hospital patients. The reports of living children taken in this way may be considered

as very accurate, but slightly fewer deaths will naturally be reported than in the hospitals because of the reluctance to divulge such information.

A third procedure consisted in the questioning, personally and carefully, of students of different schools, who had reached an age of twelve or more years and who were able to give intelligent information about their full brothers and sisters and their half brothers and sisters. Students naturally came from a highly selected group. Their information was especially accurate with reference to living children, but less so as to the deceased. The survey was made with students from seven different groups including schools in four rural areas, one in Nanking City, a student class in the College of Agriculture, and a group of graduate assistants in the University of Nanking.

It is not intended in this paper to give even a brief review of all of the data that have been obtained from this investigation, but rather to select only such material as bears upon the relation of education to the size of the family.

In the studies made by direct survey in the eight rural districts nearly all mothers were illiterate. The fathers, however, in some instances had had some schooling. Table I presents a comparison of these mothers

TABLE I—COMPARISON OF FAMILIES OF MOTHERS IN RURAL DISTRICTS STUDIED BY DIRECT SURVEY

GROUP 1—Mature Mothers Whose Husbands Had Had Five Years or More of Education

Place	Number of Mothers	Living Children	Average	Dead Children	Average	Total Births	Average
Kiangsi	62	233	3.76	122	1.97	355	5.73
Nanhsuchow	17	51	3.00	37	2.18	88	5.18
Yenshan	8	33	4.12	11	1.37	44	5.50
Hunan	20	64	3.20	68	3.40	132	6.60
Shantung ..	12	38	3.17	27	2.25	65	5.42
Unhsien	23	80	3.48	39	1.70	119	5.17
Tongshan ..	10	37	3.70	40	4.00	77	7.70
Kiangsu	12	41	3.42	10	.83	51	4.25
Total	164	577	3.52±.08	354	2.16±.11	931	*5.68±.13

GROUP 2—Mature Mothers Whose Husbands Had Had from One to Four Years of Education

Place	Number of Mothers	Living Children	Average	Dead Children	Average	Total Births	Average
Kiangsi	11	33	3.00	40	3.63	73	6.63
Nanhsuchow	9	22	2.44	27	3.00	49	5.44
Yenshan ..	13	45	3.46	16	1.23	61	4.69
Hunan	16	51	3.19	80	5.00	131	8.19
Shantung ..	4	21	5.25	19	4.75	40	10.00
Unhsien	2	7	3.50	4	2.00	11	5.50
Tongshan ..	6	21	3.50	17	2.83	38	6.33
Total	61	200	3.28±.08	203	3.33±.08	403	6.61±.17

GROUP 3—Mature Mothers Whose Husbands Had Had No Education

Place	Number of Mothers	Living Children	Average	Dead Children	Average	Total Births	Average
Kiangsi	6	18	3.00	12	2.00	30	5.00
Yenshan	21	69	3.29	33	1.57	102	4.86
Hunan	3	11	3.67	16	5.33	27	9.00
Shantung ..	62	192	3.10	201	3.24	393	6.34
Unhsien	62	184	2.97	96	1.55	280	4.52
Tongshan ..	5	14	2.80	17	3.40	31	6.20
Kiangsu	22	42	1.91	13	.59	55	2.50
Total	220	658	2.99±.08	513	2.33±.09	1171	5.32±.13
Grand total	411	1352	3.29±.04	1047	2.55±.07	2399	5.84±.09

*These means and probable errors are calculated from the total frequency distribution. All decimals beyond two places up to and and including even 5 are dropped, over 5 a digit is added.

in three groups according to the education of the husbands. Group 1 includes mothers whose husbands had received five or more years of schooling. The mothers in Group 2 had husbands whose years in school varied from one to four. In Group 3 mothers with illiterate husbands were included.

The three cultural levels as defined are by no means comparable to groups with similar periods of schooling in the United States.

Economic pressure in China makes education a privilege of the select few. Men with even a few years in school have established themselves in a class distinctly superior to the illiterates while those who have mastered the classics make up the honored and influential gentry, the recognized leaders of country life.

Women, too, even though illiterate are carefully graded into social levels through the selection of brides by parents with due regard to class and social standing.

Only those mothers are considered in Table I that we may term mature, provided we define a mature mother in this case as one who has reached or passed the age of forty years in Chinese reckoning, or thirty nine years of actual age. The use of this degree of maturity is convenient for a number of reasons. If the age of forty-five years and over should be taken, a larger number of children would be deceased who have already grown up and become parents them-

TABLE II—COMPARISON OF FAMILIES OF THE MOTHERS OF STUDENTS

Place	Number of Mothers	Living Children	Average	Dead Children	Average	Total Births	Average
GROUP 1—Literate Mothers with Literate Husbands							
Han Kwan University of Nanking	31	142	4.58	35	1.13	177	5.71
Assistants	5	17	3.40	13	2.60	30	6.00
College students	12	58	4.83	31	2.58	89	7.42
Weihsien	4	15	3.75	7	1.75	22	5.50
Nanhsuchow	21	76	3.62	48	2.29	124	5.91
Kwantung	2	10	5.00	5	2.50	15	7.50
Total	75	318	4.24±.20	139	1.85±.13	457	6.09±.24
GROUP 2—Illiterate Mothers with Literate Husbands							
Han Kwan	25	89	3.56	42	1.68	131	5.24
College assistants ..	11	45	4.09	11	1.00	56	5.09
College students	15	64	4.27	25	1.67	89	5.93
Weihsien ..	8	29	3.62	6	.75	35	4.37
Nanhsuchow	73	246	3.37	115	1.58	361	4.95
Kwantung	39	136	3.49	67	1.72	203	5.21
Nanking ..	28	102	3.64	27	.96	129	4.61
Total	199	711	3.57±.08	293	1.48±.07	1004	5.05±.11
GROUP 3—Illiterate Mothers with Illiterate Husbands							
Place	Number of Mothers	Living Children	Average	Dead Children	Average	Total Births	Average
Han Kwan	4	11	2.75	3	.75	14	3.50
College students	5	21	4.20	12	2.50	33	6.50
Nanhsuchow	28	92	3.28	52	1.86	144	5.14
Nanking	2	8	4.00	0		8	4.00
Total	39	132	3.38±.19	67	1.72±.30	199	5.10±.31
Total for series	313	1161	3.71±.07	499	1.59±.07	1660	5.30±.09

selves, and a smaller number of mothers would be available for consideration. The age chosen eliminates most of the inequalities that result from comparing women differing widely in age and years married, and gives a fairly accurate idea of the size of a mature family with the proportion of births and deaths after the critical period of infancy and early childhood has been passed by the majority of the individuals.

In the table we find that the 164 mothers of group 1 gave birth to an average of 5.68±.13 children which is quite similar to the average of the whole group. But as the number of deceased children is less than the average of the whole group the number of living children is 3.52±.08 which is the highest for the series. The mothers in group 2 had an average number of living children similar to the general average, but the living children of mothers with illiterate husbands numbered least with an average of 2.99±.08.

The difference between the average number of living children of the most cultured and of the least cultured groups is .53±.11. As this number is 4.8 times its probable error the chances are 825 to 1 that the difference is significant.

A more detailed examination of Table I makes the evidence still more convincing. When we consider that the data were collected in eight different areas it is important to see to what extent the separate findings corroborate the conclusion. In six out of the eight surveys we find an

TABLE III—COMPARISON OF FAMILIES OF FATHERS OF STUDENTS

GROUP 1—Literate Fathers with Literate Wives

Place	Number of Fathers	Living Children	Average	Dead Children	Average	Total Births	Average
Han Kwan	31	147	4.74	38	1.22	185	5.97
College assistants ..	4	14	3.50	11	2.75	25	6.25
College students	12	59	4.92	31	2.58	90	7.50
Weihsien	4	16	4.00	7	1.75	23	5.75
Nanhsuchow	21	78	3.71	49	2.33	127	6.05
Kwantung	2	10	5.00	5	2.50	15	7.50
Total	74	324	4.38±.22	141	1.91±.14	465	6.29±.24

GROUP 2—Literate Fathers with Illiterate Wives

Place	Number of Fathers	Living Children	Average	Dead Children	Average	Total Births	Average
Han Kwan	25	98	3.92	45	1.80	143	5.92
College assistants ..	10	52	5.20	15	1.50	67	6.70
College students	15	66	4.40	28	1.87	94	6.27
Weihsien	8	30	3.75	8	1.00	38	4.75
Nanhsuchow	73	262	3.59	126	1.73	388	5.31
Kwantung	38	159	4.18	87	2.29	246	6.47
Nanking	28	110	3.93	32	1.15	142	5.07
Total	197	777	3.94±.10	341	1.73±.09	1118	5.67±.14

GROUP 3—Illiterate Fathers with Illiterate Wives

Place	Number of Fathers	Living Children	Average	Dead Children	Average	Total Births	Average
Han Kwan	4	11	2.75	3	.75	14	3.50
College students	5	21	4.20	12	2.40	33	6.60
Nanhsuchow	28	92	3.28	54	1.93	146	5.21
Kwantung	2	8	4.00	0		8	4.00
Total	39	132	3.38±.19	69	1.77±.30	201	5.15±.31
Total for series	310	1233	3.98±.09	551	1.78±.07	1784	5.75±.11

increase, usually marked, in the number of living children of group 1 over group 3. With the two exceptions the difference is within the range of probable error and even with these a smaller number of deaths in families where the father is educated is indicated. The higher number of deaths in the small group of mothers with husbands having from one to four years of education was influenced by the data from the Hunan region which had the largest proportion of individuals and the highest death rate. It will be seen here that four out of the seven regions in this group really had fewer deaths than did the illiterates.

Table II presents a comparison of mature mothers of students. Here we find that in group 1 where both father and mother were literate that there were 6.09±.24 children born and 4.24±.20 living. With group 2 where the husbands were literate but the mothers illiterate there were 5.05±.11 children born and 3.57±.08 living. Group 3 with both parents illiterate averaged 5.10±.31 children born and 3.38±.18 living.

Although information obtained from students will reveal fewer deaths than that taken by the other methods described, yet without allowing for this factor we find no indication of a reduction in births as a result of education.

Seven-tenths of an adult son is left by the average leading scientist in the United States, to perpetuate his name, according to Cattell.[1] Graduates of Harvard from 1891 to 1900 have at the present time, Phillips states, an average of 1.43 living children each.[2] Green and Hunt tell us that Michigan State College graduates who had been out twenty-five years or more had an average of 2.32 children.[3] In marked contrast with these figures is this cultured group in China with 6.09 births and 4.24 living children.

The difference between the averages of the living children of group 1 and group 2 in Table II is .67±.22. As this difference is three times its probable error the odds are twenty-two to one that it is significant.

Again the uniformity of the figures from regions considered separately corroborates the conclusion from the general averages. The single exception to an increase in number of living children of group 1 over group 2 is found with the college group of only five individuals. Similarly the one exception in group 3 that does not show fewer living children than group 2 has only two individuals.

Another factor bearing upon the rate of reproduction of the cultured groups is the relatively larger family of the father. Although widows do not usually remarry, the necessity for sons which the rites of ancestor worship compel, requires that a man take an additional wife or wives if the first is unproductive, and replace rather promptly a wife that is deceased. But remarriage and plural marriage is less practical where poverty pinches than among the well to do who are also the cultured group.

It was possible to secure informa-

TABLE IV—COMPARISON OF FAMILIES OF LITERATE WITH ILLITERATE MOTHERS WHERE THE MOTHER'S AGE IS LESS THAN 39 YEARS

		No.	Av'r'ge yrs. Married	Living Children	Av'r'ge	Deceased children	Av'r'ge	Total	Av'r'ge
Tsinan Hospital	Lit.	19	5.32	21	1.11±.11	15	.79±.29	36	1.90±.53
	Illit.	30	5.97	21	.70±.14	22	.70±.22	43	1.40±.18
Peking Hospital	Lit.	35	6.01	53	1.51±.20	18	.51±.10	71	2.03±.33
	Illit.	32	6.79	37	1.16±.06	23	.72±.19	60	1.88±.29
Nanking Hospital	Lit.	43	7.49	52	1.21±.18	28	.65±.10	80	1.86±.40
	Illit.	74	8.04	76	1.03±.11	50	.66±.08	126	1.70±.20
Nanking Direct Survey	Lit.	28	7.37	57	2.11±.26	18	.67±.12	75	2.78±.39
	Illit.	20	7.75	34	1.70±.23	18	.90±.12	52	2.60±.34

tion regarding the total number of children of most of the fathers of the students whose mothers were compared in Table II. Table III sets forth the size of fathers' families. In group 1 we find there are 4.38 living out of 6.29 births and in group 2, 3.89 living children out of 5.63 births. The illiterates in group 3 averaged 3.38 living children out of 5.15 births. In groups 1 and 2 combined we find that the 271 educated fathers had 1,583 children born to them as compared with 1,461 births from 274 mothers. The educated fathers thus had 9.5 per cent more children than the mothers. The 39 illiterate fathers on the other had only 201 children to 199 for the 39 mothers, an increase of only 1 per cent.

The criticism may be made that the parents who have studied received the old fashioned education of China and that modern culture will tell a different story. It is possible to derive some data on this point from the records taken in hospitals. In Table IV the families of mothers of less than 39 years of age are considered. These groups are not only of young mothers but of those living in the large cities of Nanking, Peking, and Tsinan, where education of a modern type has prevailed for a longer time than in most other parts of China. Three of the groups give information obtained in hospitals while the fourth is from direct survey.

Throughout the series literate women are compared with illiterates and with remarkable uniformity show in spite of a slightly shorter period of married life a greater average number of births, proportionately fewer deaths and a greater number of surviving children.

Although the limited number of individuals renders the result calculated from any one group of the series of small significance, yet when we consider the series as a whole we find that there is a mean difference for the four groups of .34 living children. When this difference is considered by using Student's table for determining probability we find the odds are 322 to 1 that it is significant.

When these facts are considered from the standpoint of biological selection, the question may be raised whether education in China is really a criterion of capacity or only an evidence of opportunity. To those who know Chinese village life intimately, there is no doubt about the natural superiority of the educated. With many families poverty prevents the giving of education to all of the children, but some one out of the group may be selected to bring honor to the family by becoming a scholar. Sometimes a whole clan will pool their resources to give such an opportunity to one of their number. On such occasions the brightest child is selected with rare intuition. Moreover, the intellectual difficulties in mastering the Chinese characters and classics weed out the dullards at an early date.

Another consideration enters into the situation through the custom of adoption. To the scholar who has mastered the teachings of the sages, the ceremonial obligations, particularly of ancestor worship, are most binding. This fact explains the greater desire for sons on the part of the most cultured, who at the same time are usually the most well-to-do. If a man of standing in his community fails to have sons either by his first wife or by the second which he must take if necessary, then in the language of the sages he has committed the gravest sin against society. He has permitted the chain connecting the ancestors of the past with the living worshippers to be broken through failing to continue the male line. But a means of reestablishing himself is available. He may adopt a son from a relative or a friend. Because of economic pressure surplus sons of others are always available.

The chances are, therefore, favorable that the most brilliant youth that may be obtained is adopted.

Summary

The size of Chinese families was studied by the sample method in which data were collected from nineteen different sources and in three different ways.

The evidence so accumulated indicates that for the regions studied, education of parents results in increase rather than decrease in the number of living children. The groups from the highest cultural levels tend to leave the most survivors and reproduce substantially more than their own number.

Education is not solving China's problem of overpopulation, but rather contributing to it. It is conceivable that when the type of education changes so that instead of intensifying the ceremonial obligations to the dead ancestors which is the basic cause of over multiplication, and shifts the whole philosophy of life to an interest in the welfare of the living, then an effect upon reproduction may result that is similar to that observed in Western nations.

Birth control propaganda as a means of relieving the situation, regardless of its possibily desirable effects in other nations, would in China touch only the cultured groups and have no other result then to break down the favorable biological selection which is at present the only hopeful feature of China's population growth.

Literature Cited

1. Cattell, J. McKeen. Families of American Men of Science, II. Marriages and Number of Children. *Scientific Monthly,* Vol. IV, pp. 248-262. March, 1917.

2. Phillips, John C. Further Studies of the Harvard Birth Rate—Class of 1891-1900. *The Harvard Graduates' Magazine.* March, 1926.

3. Green, C. V. and H. R. Hunt. Birthrates in the Families of Michigan State College Graduates. *Journal of Heredity,* Vol. 16, No. 10, pp. 361-365. 1925.

How the World Is Made

High Lights of Geography—North America, *by* David Starr Jordan and Katherine Dunlap Cather. Pp. 358. World Book Co., 1925.

A book for boys and girls between the ages of ten and fourteen, when they are most curious about the earth and its inhabitants. The authors have a broad conception of the field of geography and of the interests of children. The manner of the development of the story of the world and the life upon it and the well-chosen illustrations make the book worthy of special notice. Fathers and mothers will find it well worth reading, and a valuable help in giving their children a love for the land in which they live.

In the first chapter is told the story of the formation of the world, and of the rocks and mountains. The second chapter tells of the heat forces within the earth, the third of the mountains which flame and smoke, the fourth of the glaciers, the fifth of the lakes, the sixth of rivers. Later chapters deal with erosion, the deserts, the seas, mineral deposits, the development of life, and with the living forms of today.

We need more such books to help children understand and love the world about them. The truths of evolution, heredity, and the development of life will be readily accepted by children who have had the opportunity to read such books.

G. M. D.

A PECULIAR FORM OF STERILITY

Figure 9

Raspberry fruit clusters from seedlings of the hybrid Winfield × Golden Queen. The stem at the right shows a form of sterility similar to that in the strawberry where the first blossoms to open are the most likely to set, the pistils of later flowers being sterile. Hybrids between Winfield and Cuthbert showed this same form of sterility, while in other crosses it was not detected.

RASPBERRY BREEDING EXPERIMENTS

Hybrids and Back Crosses Between Red and Black Varieties

GEORGE M. DARROW

THE evolution of the cultivated raspberry may be credited to three more or less separable lines of improvement. The first cultivated varieties consisted entirely of selections of desirable wild plants and of seedlings appearing around the gardens and within cultivated raspberry fields. Better and better sorts were continually found and replaced those that were used before. Of the important varieties grown today, Ranere, Cuthbert, Farmer, and Gregg had such an origin. Selections of wild plants are still being made and are essential in securing characteristics not now represented in cultivated sorts or which are present only in undesirable combinations. Thus, selection for such characters as fall-fruiting (both black and red), mosaic-resistance, thornlessness and hardiness is still most desirable.

The second method of improvement is the growing of seedlings and the crossing of the varieties selected from the wild to secure the best combination of their inherent characteristics. Marlboro, King, and Cumberland are among the well-known older varieties secured as the result of the growing of seedlings.

In recent years a number of valuable varieties have been originated as the result of systematic crossing. The constructive practical work of private breeders and of experiment stations has given recombinations of desirable characters in some of the varieties now rapidly coming into favor. Thus, the South Dakota Experiment Station has introduced several red varieties sufficiently hardy to withstand conditions in the Northern Great Plains. The Latham, originated by the Minnesota Experiment Station, is proving to be extremely valuable, not only in Minnesota but also in the East. Several varieties introduced by the New York Experiment Station are becoming well known. The Newman, originated by Mr. C. P. Newman, of Quebec, and the Viking, originated by the Ontario Horticultural Experiment Station, are other valuable new introductions. No chance seedling equalling any of these has been discovered in recent years.

The third line of improvement is the utilization of the principles and information made available by plant breeding and related sciences. Thus the systematic botanist has collected, described and determined, to an extent at least, the relationship of over one hundred species of raspberries. Plant explorers have collected many of these for the use of breeders. The chromosome number and pollen condition of many species and varieties have been studied by cytologists. Breeders have successfully used some of these species and have reported on their results. Disease resistance and other characters are being studied and pure lines are in process of development. The results of such work enable the breeder to introduce new characteristics more intelligently into the varieties he attempts to produce.

In a study of the chromosome number of many raspberry species and varieties, Longley and Darrow[6] report the basic chromosome number as seven. This holds true except for a small group of fall-fruiting horticultural varieties commonly referred to *R. idaeus*, the European red raspberry, which has twenty-one chromosomes. This extra-chromosome group has produced sterile or nearly sterile hybrids with other red raspberries.

FRUIT CLUSTERS OF WINFIELD × MARLBORO HYBRIDS

Figure 10

Nearly all the seedlings from this cross were partially or entirely sterile like the cluster at the right. At the left appears a selection which is quite fertile.

while crosses of species differing quite widely in appearance have given fertile seedlings. Apparently, raspberry species are capable of wide crossing.

The Van Fleet raspberry, a horticultural variety resulting from *Rubus innominatus* × *Cuthbert,* furnishes evidence of the possibilities of species crossing. In this variety is combined the great vigor, disease-resistance and productiveness of *Rubus innominatus* with some of the quality of fruit of the Cuthbert.[3]

Classification of Raspberry Species

Most of the large number of species of raspberries are native to eastern Asia. They vary greatly, from those with simple to those with compound leaves, from trailing to erect-growing forms and from small-fruited species to those with berries two inches in diameter. A few are hardy in the northern part of the United States. By far the greater number are native to regions with a climate resembling that of the southern states.

The species which enter into our common cultivated varieties are few in number. They are *R. occidentalis, R. strigosus* and *R. idaeus.* To the first species belong the black raspberries and to the second and third belong the red raspberries. Focke, Fernald and Bailey, however, consider *R. strigosus* a variety of *R. idaeus.* These authors would refer all cultivated raspberries to two species only, *R. idaeus* and *R. occidentalis,* Whether *R. strigosus* is to be considered a botanical variety of *R. idaeus* or a distinct species, however, is not of especial importance, but it is important that horticulturists and breeders keep clearly in mind the difference between the two and classify varieties accordingly. As botanical classification is for the purpose of aiding the student and the worker and not merely a mental exercise, it should be interpretive as far as possible. Because of the importance of the native red raspberry in American horticulture and its generally distinctive character, it seems preferable to retain *Rubus strigosus* as a specific term, as is here done.

Raspberry varieties have been clasified according to whether they are true species or hybrids.[2] The varieties, Eaton, King, Latham (*Minnesota No.* 4), Perfection, Ranere, and Sunbeam represent *R. strigosus;* Antwerp, Buckeye, Superlative, and Surprise, *R. idaeus;* and Cuthbert, Golden Queen, Herbert, June, and Marlboro, *idaeus* × *strigosus.* Bailey,[1] however, refers Buckeye and Erskine (*Erskine Park*) of the fall-fruiting extrachromsome *Rubus idaeus* group and Twentieth Century, which clearly belongs with these, to his variety *strigosus.* Many other varieties which are apparently hybrids with *Rubus idaeus,* are included by him under the botanical variety *strigosus.* He further confuses horticultural students by placing all hybrids between black and red raspberries in a single group as hybrids between *R. occidentalis* and *R. idaeus* var. *strigosus* and giving it specific rank as *R. neglectus.* Bailey's classification cannot be sustained, as morphological characters clearly indicate that several of the common purple varieties are multiple hybrids of *Rubus occidentalis, R. idaeus,* and *R. strigosus.* The classification of purple varieties assumes importance when it is remembered that the Columbian, the purple variety which is decidedly the leading sort of this hybrid group, is not very hardy and, in consequence, is grown in extensive commercial plantings only in a restricted region in New York State. On the other hand, hybrids between the black raspberry and the hardier red sorts derived from *R. strigosus* may be hardy in all regions where the red varieties are grown. Evidence to this effect is found in the greater hardiness of the Cardinal, a purple variety which has more of the characteristics of the American species than has the Columbian. Breeding results given below indicate obvious differences in the hybrids, depending

on the red variety used—whether it belongs to the American or to the European group.

Black × Red Raspberry Crosses

In many attempts, at the U. S. Horticultural Field Station, to use the red raspberry as the seed parent in crossing black and red raspberries no true crosses have ever been secured by the author. All successful crosses have resulted from using the black raspberry as the mother plant. No reason for this is known. Few, if any, true red × black crosses have been secured at the New York Experiment Station at Geneva in their extensive raspberry breeding work.

A private breeder, Mr. Harlow Rockhill of Iowa, has reported opposite results—crosses of the red by the black raspberry. In a letter to the author, he states:

> In regard to raspberry crosses—Older (a black raspberry) blooms so early that buds for working are hard to find when Latham is first ready. This is one reason why I have used Older on Latham. Another thing, I have not secured any fruit where red raspberry pollen was used on a blackcap variety. I tried many blossoms last year; not one fruit set.—H. Rockhill. March, 1923.

A large number of black × red raspberry seedlings have been grown at the U. S. Horticultural Field Station at Bell, Maryland, during the past few years. In 1925, 115 seedlings of the cross "Shiebley" (an unidentified black raspberry variety) × King fruited. These were all typical purple raspberries, bearing purple fruit with the usual vigor of the hybrid purple group. Furthermore, their inflorescences were glandular, this character being inherited from the King. Nearby there were ten plants of the cross Gregg × Wisbeck (*R. idaeus*), all of which lacked the glandular inflorescence. The cross Shiebley × King gave no seedlings which set all their drupelets well, and many of the flowers were nearly sterile. This result with King accords with that reported[3] in 1924 where crosses of *R. innominatus* × King set fruit imperfectly.

In 1924 and 1925 other hybrids between black and red varieties fruited. Most of the plants of the cross "Shiebley" × Ranere were affected with virus diseases and were destroyed and no record of individual bushes was made. In general, this cross gave fertile progeny.

In 1925, records were taken on the setting of a number of crosses. These are summarized in Table I.

Of the six sets of crosses, the first three listed in Table I are similar in their behavior as to the setting of fruit. The Winfield × Cuthbert and Winfield × Golden Queen seedlings were planted side by side and when in fruiting could not be distinguished. Apparently, Golden Queen is an albino sport of the Cuthbert, but the color characteristic lost may be the result of the action of any one of several genes affecting color, or may not enter at all into the genes affecting color of the cane and fruit of the purple varieties, as was suggested by Thayer[7] who secured albinos as the result of a cross of the albino black with the albino red.

The Winfield × Marlboro crosses were, for the most part, quite sterile

TABLE I. THE SETTING OF BLACK × RED RASPBERRY HYBRIDS—JUNE 26, 1925

Hybrid	Pop.	Plants selected		Plants well set		Plants poorly set		Plants sterile		Plants not ripe	
		No.	%	No.	%	No.	%	No.	%	No.	%
Winfield × Cuthbert	675	3	0.4	41	6.1	626	92.7	5	0.7	....	....
" × Marlboro	193	2	1.0	25	13.0	160	82.9	6	3.1	....	....
" × Golden Queen	192	2	1.0	31	16.1	159	82.8	....	....	....	....
" × Ontario	338	21	6.2	223	66.0	91	26.9	4	1.2	....	....
" × Newman	207	27	13.0	117	55.5	41	19.8	4	2.0	18	8.7
Farmer × Latham	40	13	32.5	26	65.0	1	2.5	....	....	....	....
Total	1645										

PURPLE FRUITED HYBRIDS

Figure 11

Crosses of the Winfield black raspberry with the Ontario red variety. The first cluster to the left is from a partly sterile seedling, while the center and right clusters are from a selection. In these experiments no crosses were obtained when the red varieties were used as the pollen parent, though the reciprocal cross regularly produced viable seed.

VARIATION IN FERTILITY OF HYBRIDS

Figure 12

At the right is a branch of one of the least fertile of the seedlings resulting from the cross Winfield × Newman. At the left is a cluster of a selection of the same cross. This cross has produced the most promising purple seedlings of any yet fruited.

but the plants were more vigorous than the crosses using Cuthbert and Golden Queen as pollen parents.

When Ontario was used as a pollen parent the bushes on the average were the largest in size of any set of black × red crosses, though perhaps not larger than a few bushes of "Shiebley" × Ranere parentage. As a group, the plants fruited much better than the first three sets of crosses listed in Table I. The drupelets were larger and the average season of ripening was much earlier than in those of other crosses noted. Some of the selections bore very large fruit.

The crosses Winfield × Newman and Farmer × Latham gave more vigorous seedlings than when Cuthbert or Golden Queen were used as pollen parents. The foliage of the seedlings was darker green than when Cuthbert or Golden Queen was used. The percentage of selected seedlings from these two crosses was much the largest of any of the crosses, being 13% in the cross of Winfield × Newman and 32.5% in the cross Farmer × Latham. From these results it appears that Latham and Newman are much the best parents to use in breeding. Recent trials indicate that they are the hardiest commercial red raspberries grown in this country and the hybrids with these varieties also may inherit this hardiness.

King, Cuthbert, Golden Queen, and Marlboro have given poor results as parents in the work reported here. Some of the varieties which have been promising in the work of other breeders have given poor results in the work under discussion. Thus, Van Fleet used Cuthbert in securing the Van Fleet variety. The Viking, a promising new variety of great vigor, large size and exceptional dessert quality, being introduced by the Fruit Breeding Station, Vineland, Ontario, is a cross of Marlboro × Cuthbert. Moreover, each of the first four varieties introduced by the New York Agricultural Experiment Station at Geneva has Marlboro as one parent. These are Donboro and Louboro crosses of Loudon × Marlboro, Marldon, a cross of Marlboro × Loudon and Marlative, a cross of Marlboro × Superlative.[5] The June, introduced by the same station in 1909, is another Loudon × Marlboro cross. Latham, introduced by the Minnesota Experiment Station is reported as a cross of King × Loudon. Apparently, in crossing with red raspberries the Cuthbert, King, and Marlboro are sometimes valuable, though not when the Winfield black variety is used.

The expression of sterility in the Winfield × Cuthbert and Winfield × Golden Queen hybrids was peculiar in that the first blossoms to open were the most fertile of all and the later flowers were more or less sterile (see Figure 9) just as occurs in the strawberry.[4]

In the Winfield × Marlboro and in other hybrids a similar expression of sterility occurred occasionally. Usually, however, in these latter hybrids some drupelets set in nearly all flowers of those clusters where the first flowers set, as shown in Figures 10, 11 and 12.

Purple × Red Raspberry Back-crosses

A hybrid between the red and the black raspberry is commonly called a purple raspberry because of the color of the fruit. In certain characteristics such hybrids show great uniformity. All propagate by rooting at the tips; none send up suckers. In varietal hybrids they are prickly, not bristly. The fruiting habit (see Fig. 14) also resembles that of the black rather than that of the red type. The berries are commonly purplish and not black or red. Usually the proportion of pulp to seed is greater in the hybrid than in either red or black sorts and the purple sorts are preferred for this reason, as well as for their flavor, for jams and canning. The reasons why they have not superceded the black and red varieties lie in the tenderness of the varieties in the trade to winter injury and in the

PROMISING SELECTIONS PRODUCED BY CROSSING

Figure 13

A back cross of the purple raspberry (Royal) by the red (Newman). This cross was made in the hope of combining some of the desirable characteristics of the two types. Note that the fruit is much more exposed, hence, is more easily picked than are the common red raspberries.

Figure 14

A hybrid of the Farmer black raspberry by the Newman red raspberry. Note the large clusters of this purple raspberry, also the exposed position of the berries which makes picking easier than with the red varieties.

unattractive appearance of the fruit on the market.

Back-crosses of the hybrid with the red were made in an attempt to secure red-fruited sorts with the superiorities of the purple. A number of such back-crosses fruited in 1924. They ranged in color from red to purple and it became evident that to secure varieties with the desired color only the single back-cross was necessary.

The back-crosses were of Royal × Newman and Royal × Latham parentage. Less than 50 seedlings of these crosses were fruited but the percentage of desirable selections was high. There was less tendency for them to root at the tip than with the purples, while several seedlings sent up suckers more or less freely. Many had the fruiting habit of the purples (Figure 13) though others had fruiting habits grading to that of the reds. Apparently, a weakness of these back-crosses is the difficulty in securing selections which propagate readily. In general, a variety rooting at the tip is probably more desirable commercially than one which suckers.

The back-crosses showed one characteristic, however, which was apparently new. The fruit borne by many of the seedlings was firmer than that of either parent and firmer than that of any red, black or purple variety of raspberry known.

The range in season of ripening was also greater than that of the red, purple or black raspberries. None was as early as some varieties of red raspberries but this can be explained by the fact that the parents, Newman, Latham and Royal are all late varieties. Some of the selections were, however, much earlier in season than these sorts—ripening about with the black raspberries. Others were later than any red, black, or purple sorts now on the market. In fact, some did not begin to ripen their fruit until after the season of the Newman, Latham, and Royal had passed. In all, the ripening season of the back-crosses covered a period of nearly two months.

The ripening season of raspberries has an important effect on their propagation. The common black raspberries root at their tips freely in August and sometimes even in July and little difficulty is experienced in getting strong, well matured tips. Probably on the average the strongest tips are secured from the tips of plants set the previous spring. The purple varieties now in the trade mature their crop later than the black sorts and likewise they start rooting at the tips of the turions later in the season. It is generally more difficult to secure strong well-matured tips from the purple than from black varieties on this account. From bearing fields it is still more difficult to secure good propagations of the purple varieties.

The attempts at propagation of the selections from the back-crosses have corresponded with the usual commercial experience. The early-fruiting selections of those which have the general bush appearance of the black and purple sorts have rooted fairly well while the late-ripening selections have, in general, rooted at the tip late in the season or not at all. Apparently, selections of easily propagated sorts followed the fruiting of large numbers of seedlings or the use of different parents, or special practices in propagation will be necessary before commercial production of very late-fruiting back-crosses will be possible.

Summary

1. In the raspberry breeding work at the U. S. Horticultural Field Station no hybrids have been secured when red varieties have been used as the mother parent and the black as the pollen parent.

2. Hybrids between the Winfield black raspberry and the Golden Queen, an albino red variety, bore purple fruit and were similar to the seedlings resulting from the cross Winfield × Cuthbert.

the red varieties.
e exposed, hence, is more easily picked than t
fruit is much more e
are the common red raspberries.

3. Plants of Winfield × Golden Queen, Winfield × Cuthbert and Winfield × Marlboro crosses were mostly sterile; Winfield × Ontario gave much more fertile seedlings while Winfield × Newman and Farmer × Latham gave a high percentage of fertile seedlings.

4. Back crosses of the hybrid Royal by the variety Newman and Royal by the variety Latham gave a high percentage of desirable selections producing red fruit.

5. A notable characteristic of the fruit of some of the back crosses was greater firmness than in that of either parent or in any known raspberries.

6. The back crosses covered a greater range of season in ripening than in the parents, some being later than any known sort.

Literature Cited

1. Bailey, L. H.—Gentes Herbarium fasc. *Quidam Rubi Cultorum,* November, 1923, pp. 148-149.

2. Darrow, Geo. M.—Are Our Raspberries Derived from American or European Species? *Journal of Heredity*, Vol. XI, April, 1920, pp. 179-184.

3. Darrow, Geo. M.—The Van Fleet Raspberry; a New Hybrid Variety. *U. S. Dept. of Agriculture Circular* 320, August, 1924, p. 13.

4. Darrow, Geo. M.—Importance of Sex in the Strawberry. *Journal of Heredity,* 16:193-204. June, 1925.

5. Hedrick, U. P. and Taylor, O. M.—Distribution of Station Strawberries and Raspberries. Bul. 298, March, 1908, New York Agricultural Exp. Station.

6. Longley, A. E. and Darrow, Geo. M.—Cytological studies of Diploid and Polyploid Forms in Raspberries. *Journal of Agricultural Research,* Vol. 27, No. 10, March 8, 1924, pp. 737-748.

7. Thayer, Paul.—Raspberry Breeding Notes. *Journal of Heredity,* 14:13, April, 1923.

Back Numbers of the Journal of Heredity Wanted

Numbers listed below should be mailed to the office of the Association, Victor Building, 724 Ninth St. N. W., Washington, D. C., and will be paid for at the prices indicated. Unless payment in cash is requested, members' accounts will be credited with the amounts due for the Journals received from them.

Vol. V, No. 1, $2; Nos. 2, 3, 4, and 7, 50c.

Vol. VI, No. 1, 30c.

Vol. VII, Nos. 1, 2, 3, 4, 5, 30c.

Vol. IX, No. 6, 50c.

Vol. X, No. 9, $1.

Vol. XI, No. 2, $1; Nos. 1, 2, and 4, 30c.

American Breeders Magazine:

Vol. I, Nos. 1, 3, 50c.

Vol. II, Nos. 1, 2, 50c.

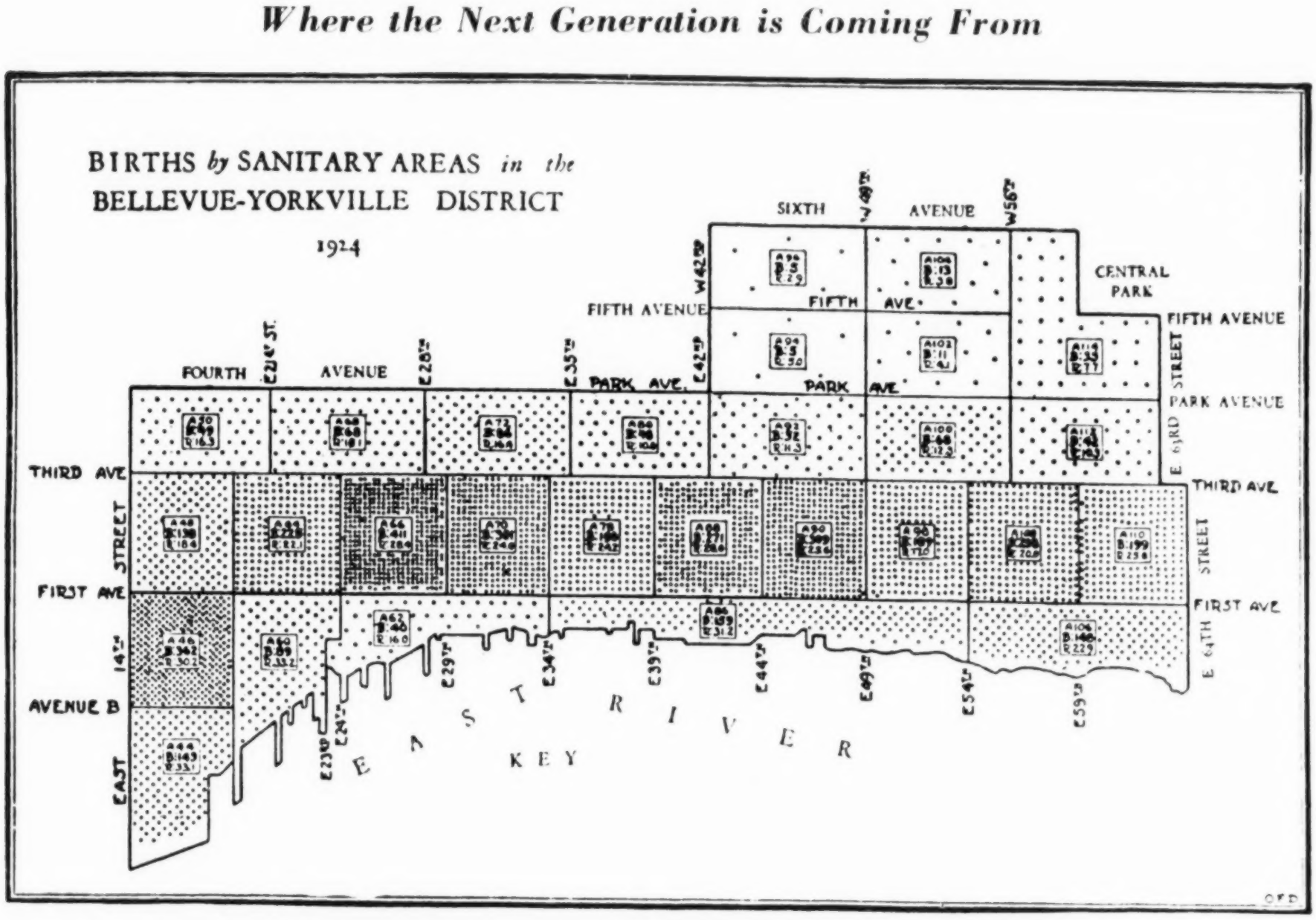
Vol. III, Nos. 1, 3, 50c; No. 4, $1.50.

Vol. IV, Nos. 2, 3, 50c.

NEWS AND NOTES

Fifth Avenue vs. First Avenue

Where the Next Generation is Coming From



THE BELLEVUE-YORKVILLE HEALTH DISTRICT

There were 3,894 babies born in the Bellevue-Yorkville District of the City of New York in 1924. As is shown here, the preponderant majority of these births occurred in the more congested residential neighborhoods. Each dot represents one birth. The total number of births in this district in 1924 was 3,894; the birth rate per 1,000 population was 21.4.

IN his talk before the recent health education conference, Godias J. Drolet, Consulting Statistician of the Bellevue-Yorkville Health Demonstration, presented the accompanying graph showing the births occurring in the several sanitary areas of the Bellevue-Yorkville district during the calendar year, 1924.

Mr. Drolet brought out that of the total 3,894 births occurring in the combined districts comparatively few were recorded in the sanitary areas bordering on Fifth Avenue. The preponderant majority were allotted to the strip lying between the East River and Third Avenue. The birth rates in the sixteen sanitary areas making up the latter zone were almost uniformly higher than those in the twelve areas encompassed by the former region. The speaker added that this is perhaps to be expected—that the more densely populated areas would be those showing the greater fecundity.

The work in maternity and infant hygiene of the Department of Public Welfare of the City of New York, the Maternity Center Association, as well as that in health education of the demonstration staff, is being planned on the basis of the data presented in this chart.

Millbank Memorial Fund Quarterly,
July, 1926.

The Cost of Crime

Salaries to Criminals

THE best informed authorities agree the annual cost of crime in this country is not far from $10,000,000,000, covering loot of about $3,500,000,000 and $6,500,000,000 as police, insurance, prosecuting and prison charges, together with the economic loss in man power.

Accepting these figures as reasonably correct, the cost of crime to each inhabitant of the United States is $83 a year.

The American Bankers' Association, with a membership of 23,000 banks, makes the following estimate covering the direct loss of property in 1925 due to crime:

Embezzlement	$120,000,000
Credit frauds	400,000,000
Burglary, larceny and petty thefts	250,000,000
Forgery and spurious checks	75,000,000
Seaport robberies, piracy and customs frauds	100,000,000
Thefts from railroads	25,000,000
Stock frauds	1,700,000,000
Tax and insurance frauds	1,000,000,000
Arson	50,000,000
Miscellaneous	75,000,000
Total money losses due to crime	$3,795,000,000

In an estimate made by Edward H. Smith for the Detroit Chamber of Commerce, with a slightly different classification, crime loot is set at $3,500,000,000. Burdette G. Lewis, Commissioner of Public Safety of New Jersey, arrives at the same conclusion.

Charles R. Holden, president of the Chicago Crime Commission, made this remarkable statement regarding the activities of the underworld in that city:

"Chicago could afford to pay its 30,000 crooks not less than $20,000 a year each to retire from business or go elsewhere. If we could do that, the expenditure of $600,000,000 would be no greater than the cost of crime to Chicago under present conditions."

Louis Seibold, Washington Evening Star,
September 9, 1926.

A Directory of Research in Child Development

THE Committee on Child Development of the National Research Council is preparing a directory of research in child development. The directory aims to secure coordination of research and cooperation among workers by facilitating interchange of material, reprints, and methods, and the organization of conferences on various phases of child research. Readers of this magazine who are engaged in research on developmental problems, particularly as they concern the child under seven years, are requested to communicate with Dr. Leslie R. Marston, Executive Secretary, Committee on Child Development, National Research Council, Washington, D. C. The directory will be mailed to those furnishing requested information.

A Request for Papaw Seeds

DR. ORLAND E. WHITE of the Brooklyn Botanic Garden, 1000 Washington Avenue, Brooklyn, New York, desires for experimental purposes small quantities of seed (18 seeds) from various localities along the southern and northern limits of the range of the papaw (*Asimina triloba*). Should any of the members of the A. G. A. be able to supply these the favor would be greatly appreciated.